THIS NUMBER COMPLETES VOLUME XVI

VOLUME XVI NOVEMBER, 1933 NUMBER 6

JOURNAL OF DAIRY SCIENCE

PUBLISHED BY THE
AMERICAN DAIRY SCIENCE ASSOCIATION

Contents

The Bull Index Problem in the Light of Modern Genetics. JAY L. LUSH 501

Lactation in a Barren Heifer. IVAR JOHANSSON AND M. H. KNUDSEN 523

Factors Contributing to an Off-Flavor in Ice Cream. C. D. DAHLE AND E. C. FOLKERS 529

The Effect of Feeding a Cod-Liver Oil Concentrate to Cows on the Vitamin D Content of Milk. W. E. KRAUSS, R. M. BETHKE AND WILLARD WILDER 549

Amyl Alcohol as a Source of Error in the Gerber Test. B. L. HERRINGTON 557

The Comparative Vitamin A Content of Nut-Margarines and Butter. CHARLES F. POE AND HAZEL A. FEHLMANN 559

The Yield and Composition of Milk from Aberdeen-Angus Cows. L. J. COLE AND IVAR JOHANSSON 565

The Formation of the American Dairy Science Association. WILBUR J. FRASER 583

Proceedings of the 28th Annual Meeting of the American Dairy Science Association 587

Membership of American Dairy Science Association 597

Index to Volume XVI 601

THE SCIENCE PRESS PRINTING COMPANY
LIME AND GRIER STREETS, LANCASTER, PA.

Made in United States of America

IT'S NOT A CRIME TO CHANGE YOUR MIND

FORMERLY Nitrogen at 15 to 20 cents a pound *was* too expensive to be used on haylands and pastures.

NOW Nitrogen in the form of Aero Cyanamid is being delivered to farmers at less than 10 cents per pound (and every ton of Cyanamid supplies 1400 pounds of hydrated lime).

IT PAYS TO USE—

AERO CYANAMID

For more, better, earlier, and later pasture.
For higher-yielding and better-quality early-cut grass hay.

DAIRY FARMERS KNOW IT

That's why a Hundred Carloads of Aero Cyanamid went on Haylands and Pastures in a few counties in New England alone in 1933.

•

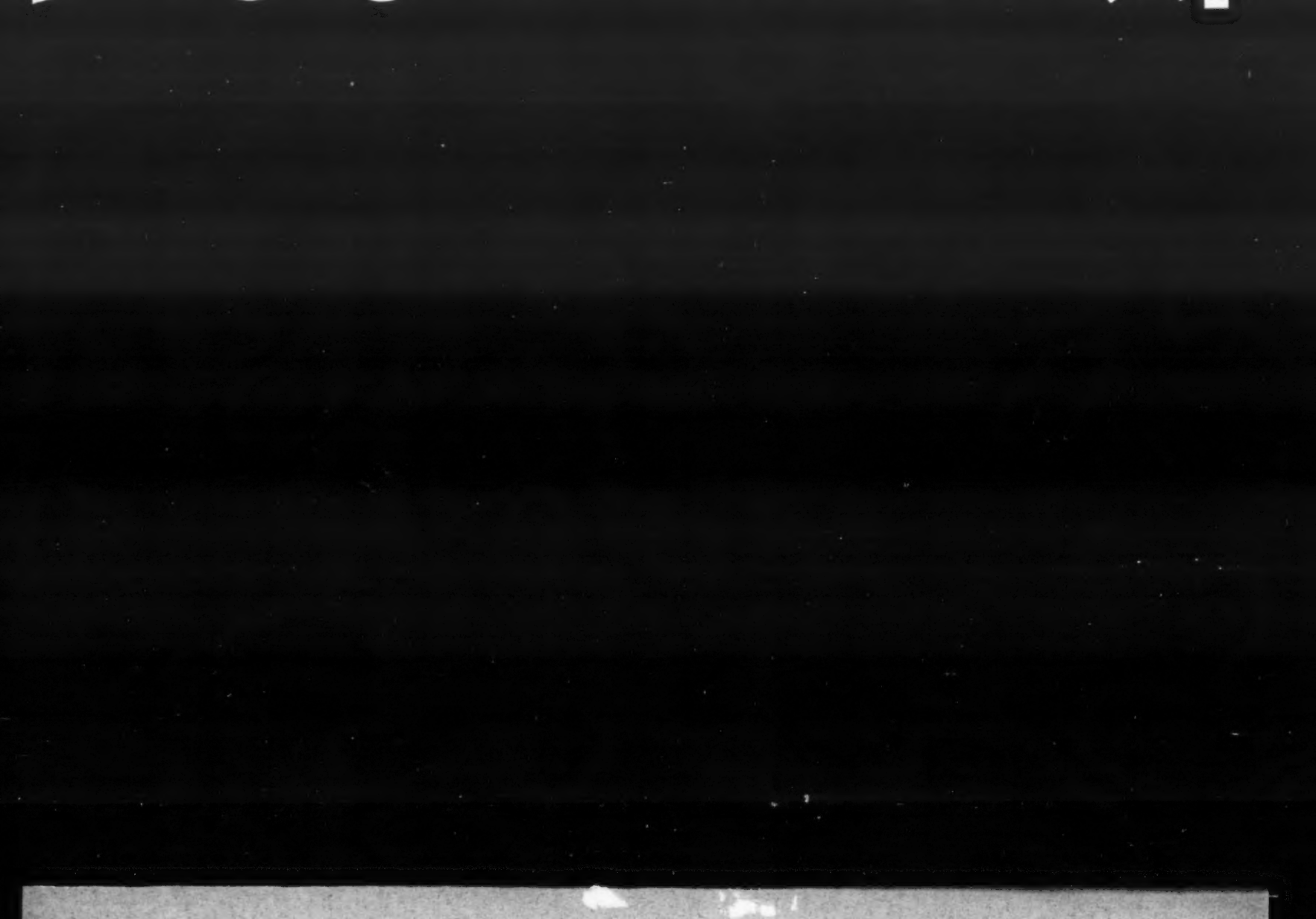
Of course, the farmer uses phosphoric acid (and potash where required) as a basic fertilizer for hay and pasture just the same as for grain crops.

But it's the Aero Cyanamid that puts pep in the grass, brings it on early, makes more of it, improves its quality, and puts milk in the pail.

AMERICAN CYANAMID COMPANY

Manufacturers of Aero Cyanamid and Ammo-Phos

535 FIFTH AVENUE NEW YORK, N. Y.



ESCO

Sterilizes Utensils *electrically!*

DIFFICULT requirements merely serve to emphasize the advantages of the ESCO Electric Utensil Sterilizer. The ESCO lends itself particularly, to bacteriological and other laboratory uses, because it substitutes the electric switch for the bother of steam and chemical methods of sterilization.

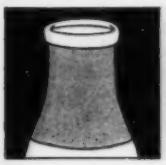
The operation merely calls for placing the wet utensils into the Sterilizer immediately upon rinsing, and switching on the current. Further action is automatic.

Amply authoritative proofs of the thoroughness of the ESCO method are available, and will be gladly sent upon request.

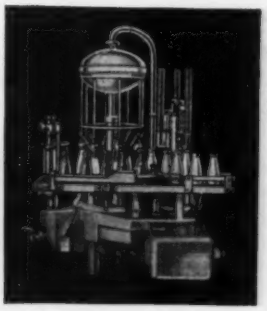
ESCO CABINET COMPANY, Manufacturers, West Chester, Pa.

VACUUM FILLED MILK

Has a Deep Cream Line



Has Better Keeping Qualities



VACUUM FILLED MILK

Insures Accurate Measure

Leaves Cap Clean and Dry

Vacuum Filling Has Many Advantages

The vacuum method of filling milk has a number of features which tend to improve the salability and increase the consumer appeal of the milk.

Vacuum filling permits handling of milk at 33° without foaming. Tests show that colder filling improves the cream line 7% to 20%, and at the same time retards the growth of bacteria. Icing costs are cut down and keeping qualities are improved.

Vacuum filling also insures an unvarying milk level, preventing loss of milk through overfilling and loss of customers through underfilling. Milk cannot rise above cap seat. Cap remains clean, dry and uncontaminated.

Mojonnier Vacuum Fillers are manufactured in 5 models, including two with a capacity range to meet the needs of the experimental creamery.

Write for illustrated bulletin giving complete details.

MOJONNIER BROS. CO.
4601 W. Ohio St. Chicago, Ill.

Mojonnier VACUUM BOTTLE FILLER

Your advertisement is being read in every State and in 25 Foreign Countries

AMERICAN DAIRY SCIENCE ASSOCIATION

INCORPORATED IN THE DISTRICT OF COLUMBIA

Officers

President ..... R. B. STOLTZ, Columbus, Ohio
Vice-President ..... C, L. ROADHOUSE, Davis, Calif.
Secretary-Treasurer ..... R. R. GRAVES, Washington, D. C.
Editor ..... A. C. DAHLBERG, Geneva, N. Y.
Director ..... E. WEAVER, Stillwater, Oklahoma.
Director ..... O. F. HUNZIKER, Chicago, Illinois
Director ..... L. A. ROGERS, Washington, D. C.

Officers of Sections

SECTION NO. 1—Dairy Production

Chairman ..... J. H. HILTON, LaFayette, Ind.
Secretary ..... S. M. SALISBURY, Columbus, Ohio

SECTION NO. 2—Dairy Manufactures

Chairman ..... J. O. BARKMAN, Lexington, Ky.
Secretary ..... P. H. TRACY, Urbana, Ill.

SECTION NO. 3—Extension

Chairman ..... C. R. GEARHART, State College, Pa.
Secretary ..... FLOYD JOHNSON, Ames, Iowa

Officers of Divisions

Southern ..... A. D. BURKE, Chairman, Auburn, Alabama
E. C. ELTING, Secretary, Clemson College, S. C.
Eastern ..... C. B. BENDER, Chairman, New Brunswick, N. J.
R. E. JOHNSON, Secretary, Storrs, Connecticut
Western ..... G. H. WILSTER, Chairman, Corvallis, Oregon
R. W. MORSE, Secretary-Treasurer, Corvallis, Oregon

The American Dairy Science Association was organized to advance the general welfare of the dairy industry, especially by the improvement of dairy instruction by the stimulation of scientific research in all phases of the subject and by improvement in methods of conducting extension work.

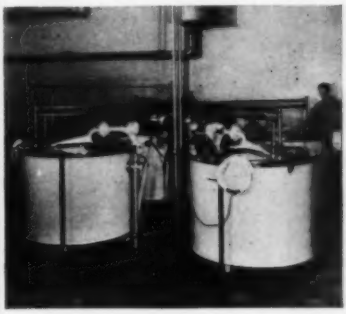
Membership shall consist of two kinds: (1) active, (2) associate.

The qualifications for membership in the two classes are as follows: (a) Any person is eligible to active membership who is formally announced by an Agricultural College, or Experiment Station, or by the Bureau of Dairying of the United States Department of Agriculture as an instructor, extension worker, investigator, or administrative officer connected with the dairy industry, or (b) anyone filling a position of responsibility connected with the dairy industry and who has had a college or University training in technical science, or anyone filling a responsible position in the industry of a professional character requiring a technical knowledge of dairying of a high order.

Any person is eligible to associate membership who is regularly enrolled in a collegiate course in a college of Agriculture and who is specializing in dairying. Associate membership is attained by election to membership in a local chapter of the American Dairy Science Association.

The dues are $5.00 a year for active membership. Correspondence regarding membership and dues should be addressed to R. R. Graves, United States Department of Agriculture, Washington, D. C.

Your advertisement is being read in every State and in 25 Foreign Countries



PFAUDLER AUTOMATIC GLASS-LINED TANK HOLDER COMPLETES SWEITZER'S MODERNIZATION PROGRAM

Fourth Detroit Dairy to Install System

Sweitzer Creamery of Detroit recently completed its modernization program with the installation of a 6000 lb. per hour Pfaudler Automatic Glass Lined Tank Holding System, illustrated above. *It is the fourth Detroit dairy to install a Pfaudler system!*

In these days of close competition the absolute necessity of cutting costs is vital . . . a Pfaudler Automatic Holder cuts pasteurizing costs!

Fully automatic, one master valve, electrically operated but requiring no complicated timing devices, controls filling, holding and discharge operations accurately. It cannot be forced; neither can it be retarded. Accurate holding is the "law."

Through the use of "Lo-Vat" glass lined pasteurizer-holders capacities from 3000 lbs. per hour and up can be obtained . . . flexible to increased requirements—also operates at 50% of any given capacity!

These features plus the ever present advantage of the sanitation and easy cleanability of glass is the answer to any plant operator who must cut costs. Full information on request.

THE PFAUDLER CO.
1515 Gas & Electric Bldg. Rochester, N. Y.

PFAUDLER
Glass-Lined
DAIRY EQUIPMENT

B-K

IS THE RESULT of 20 Years Development

The proper balance of dependable stability and quick-acting germ-killing power of B-K represents the result of 20 years intensive research and development.

B-K—because of the quick release of hypochlorous acid due to its low alkalinity—destroys bacteria *instantly on contact,* and insure uniform, efficient sterilizing solutions every time.

The excess alkalinity of many hypochlorites interferes with the quick release of hypochlorous acid, and because the time of exposure in use is so short, the greater part of available chlorine is wasted.

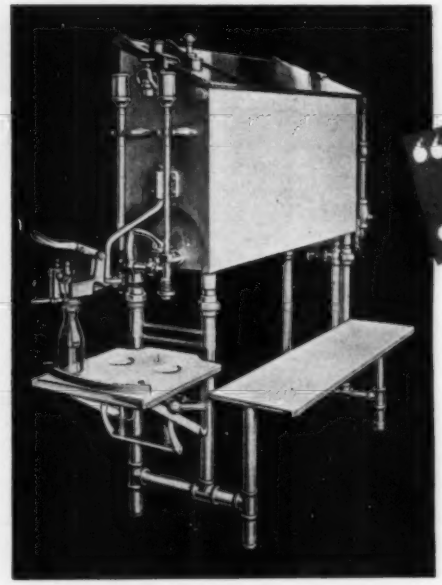
But not so with B-K. Because of its low alkalinity, B-K sterilizes both quickly and efficiently.

The New B-K POWDER

is the result of over 10 years of extensive research and laboratory tests. It contains 50 percent available chlorine and can be used either to make a stock solution or added direct to rinse water. B-K Powder carries the same guarantee for stability and quick-acting germ-killing power as B-K Liquid.

For Quantity Discounts and Interesting New Free Book, "Better Dairy Products," write to

General Laboratories, Inc.
Dept. C-11 Widener Bldg., Philadelphia, Pa.



A complete pre-cooling, storing, heating, holding, cooling, bottling and capping unit. Five items of equipment in one. The bottle filling table is easily lifted from one cross rod to another for filling quarts, pints and half-pints.

THIS SINGLE CHERRY-BURRELL UNIT DOES FIVE JOBS which used to require five separate machines . . . does them better

NOW safe milk becomes truly practical for the smaller dairies. Less equipment is required. Power and other operating costs are less. Operation is simple. Cleaning is easy. Performance is positive.

In successful operation for more than two years this Cherry-Burrell "Five-in-One" Pasteurizer, a single 60-gallon unit, replaces the separate milk cooler, pasteurizer, pump, sanitary pipe and fittings, pasteurized milk cooler and bottle filler and capper heretofore required.

With flush outlets and other advanced features of design which meet the most rigid health and sanitation requirements, easily cleaned and taken care of, moderate in cost and modern in performance this simple single unit is ideal for dairies contemplating the installation of "milking parlors"—for raw milk dairies who wish to get in line with the spreading, growing trend to pasteurization—for certified plants seeking the last word in completely safeguarded milk.

Ask us to send you illustrated, descriptive bulletin No. G-212.

CHERRY-BURRELL CORPORATION, 427 W. Randolph St., CHICAGO

Your advertisement is being read in every State and in 25 Foreign Countries

JOURNAL OF DAIRY SCIENCE

VOLUME XVI NOVEMBER, 1933 NUMBER 6

THE BULL INDEX PROBLEM IN THE LIGHT OF MODERN GENETICS*

JAY L. LUSH

Iowa State College, Ames, Iowa

There is general agreement that information about a sire's offspring is important in estimating that sire's real breeding worth. There is not the same agreement on how to use that information. The purpose of the present article is to clarify the situation by calling attention to certain genetic principles which underlie the bull index problem.

GENETIC PRINCIPLES

1. *Inheritance is Mendelian in the broadest sense of the word.* This includes such modifications as linkage and sex-linkage. Inheritance is by particles or units which are present in pairs and which maintain their identity and later segregate out unchanged, instead of blending with each other as was thought in pre-Mendelian days. That there is in the higher organisms *any* inheritance which is not Mendelian in this broad sense of the word seems unlikely. Certainly there cannot be much. There may be a few minor exceptions such as plastid inheritance in plants or polyploidy but those things are rare or unknown in animals.

2. *The genes are not adaptively modified by their environment.* This statement denies the inheritance of acquired characters and like many other negative statements may be impossible of complete and rigorous proof. However, the many extensive and carefully conducted experiments which have failed to detect the inheritance of adaptive modifications constitute impressive evidence. In order not to be dogmatic, one should perhaps keep an open mind for new evidence on this point but it is almost incredible that environment should be able to modify the genes in an adaptive way to a degree important in practical animal breeding, and yet that such modifications should have escaped detection in the many experiments planned expressly to test that point.

3. *Observed yields are affected by environment.* Strictly speaking, the question of whether a characteristic is hereditary or environmental has no

Received for publication December 24, 1932.

* Journal Paper No. B91 of the Iowa Agricultural Experiment Station, Ames, Iowa.

meaning because the genes cannot possibly produce the characteristic without the proper environment, and even in the proper environment the characteristic cannot develop unless the necessary genes are present. The characteristic is the end result of complicated interactions of genes among themselves and with their environments. There is no such thing as a disembodied gene or set of genes for a fat production of 800 pounds, for example. We may speak of a cow as being a 800 pound producer but it should never be forgotten that this applies to a particular set of conditions. Alter the conditions and the production will alter. The inheritance which would be for 800 pounds of fat under one set of conditions might just as well be called inheritance for 600 pounds under another set of conditions.

4. *The number of genes affecting each characteristic is large.* This is almost inevitably true for characteristics like milk production which are dependent on the combined functioning of many organs and organ systems and which might be raised or lowered by the altering of any one of many quite different physiological processes. The exact number of genes affecting milk and fat production matters little if it is much more than a half dozen pairs because then it will be physically impossible to learn the exact and complete genetic formula of any bull or cow.

The existence of a large number of genes and the general absence of intensive inbreeding within breeds has several other consequences:

A. No animals have *exactly* the genes the breeders desire but some have more nearly the ideal than others do. This makes it impossible to improve a herd or breed in all respects at once, simply by continually grading it up to a perfect individual, since the latter does not exist.

B. Entirely homozygous animals are so extraordinarily rare that the search for those to be used continually as sires is doomed to but partial success at most.

C. A high degree of homozygosity and the possession of a high proportion of the desired genes are uncorrelated, or nearly so. Indeed there is some evidence to show that on the whole heterozygosity rather than homozygosity is correlated with individual excellence although not necessarily with breeding worth.

5. *Gene frequency* (the proportion which a desired gene constitutes of all the genes which occupy that locus in the whole breed) is changed at a rate which would be appreciable within a breeder's lifetime only by selection; that is, by letting individuals possessing the desired genes leave more offspring than are produced by those lacking the desired genes. Mutation is so rare an event that the practical breeder need not take it into account. Random survival or extinction of genes is too weak a force to be important in a practical breeder's lifetime except in extreme inbreeding systems.

6. The *homozygosity* of a breed or other group is changed to any appreciable extent only as a result of changes in gene frequency, or (and much more powerfully) by some form of inbreeding or its opposite, the crossing of distinct strains.

7. *Genes often exhibit dominance.* This is not universal but it seems to be the usual situation, at least among genes for distinct differences in color and gross anatomy. The evidence is not so clear that either dominance or the lack of it is the usual condition among genes which have for their main effects quantitative change in a characteristic already present in some degree. There is no inherent tendency for dominant genes or recessive genes to replace each other in a population, except that undesired dominants are more exposed to the effects of selection than undesired recessives are. This has led to the general condition that undesired genes tend to be recessive and desired ones dominant, particularly if the traits which those genes affect have been the object of selection for many generations.

8. *Genes interact with each other.* Many genetic factors require the presence and cooperation of others in order to manifest their effects. These are known in genetics under various terms, such as inhibiting factors, complementary factors, epistatic factors, etc. They are most nearly summed up to the practical animal breeder in the term "nicking," although this term is ill-defined and often is used to include other phenomena such as rare Mendelian recombinations. The extensive inbreeding experiments so far carried out on animals and on corn indicate that there may be a considerable amount of such complex interaction among factors affecting size, growth rates, yield and such characteristics, which logically might be expected to be inherited in about as complicated a way as is milk production. There is not yet any very satisfactory basis for estimating whether such complex interactions among genes are the rule or are rare exceptions. Much of the gene interaction must be simply additive or multiplicative or else the observed daughter-dam and half-sister correlations could scarcely be as large as most actual studies have found them.

APPLICATIONS TO THE PROBLEM OF SIRE INDEXES

1. *Offspring average midway between parents.* The genetic fact which overshadows all others in its importance in the construction of sire indexes is that the genotypes of the offspring *average* midway between those of the two parents but any individual offspring may vary widely from that average. This is illustrated in the following example, where each capital letter represents a plus factor and the dashes indicate the unknown but probably very large number of factors omitted from the problem:

		PHENOTYPIC VALUES	
		a. No dominance. Each plus factor = 100	b. Complete dominance. Each factor pair = 150 if a plus is present
Sire:	*AABbCCDdee—Nn*	700	750
Dam:	*AaBbccDdEe——nn*	400	600
Offspring:			
Maximum	*AABBCcDDEe—Nn*	900	900
Minimum	*AabbCcddee——nn*	200	300
Average		550	675

The figures at the right show what the phenotypic values would be with certain arbitrarily assigned numbers to represent the effect of each plus factor. In both columns the average of all offspring is *midway* between the two parental values and in both the minimum offspring is below the poorer parent and the maximum offspring exceeds the higher parent.

2. *The consequences of dominance.* Those who take the trouble to juggle with such formulae as these in all possible Mendelian combinations will quickly find that *in the absence of dominance* the average phenotype as well as genotype of the offspring will be midway between the parents, *whatever the Mendelian formulae of the parents.*

If dominance exists the offspring still average midway between the parents wherever the average amount of heterozygosis among the offspring is the same as that of the parents. Where the offspring are more heterozygous than the parents (as in the first generation of a cross between two breeds) their average will be above the mean of the parents and might even exceed the higher parent (using "above" to mean in the direction of the dominant genes). Where the offspring are less heterozygous than the parents (*e.g.*, in intense inbreeding) they will average lower (*i.e.*, in the recessive direction) than the mean of the parents. For all practical purposes heterozygosis in a population *neither increases nor decreases* noticeably from one generation to another unless violent outbreeding at the one extreme or intensive inbreeding at the other are being practiced. Hence *in a population* bred as purebred dairy cattle are, the existence of dominance, even if complete, does not modify the general principle that offspring average midway between their parents.

The effects of dominance may be illustrated in another way by following the consequences of each of the six kinds of matings possible where a gene has only one allelomorph. Let $w = AA - aa$, that is, the difference between homozygous dominant and homozygous recessive phenotypes. Let the proportions of the two allelomorphic genes in the population be q A and $(1-q)a$.

Type of mating	Frequency of this mating in a population breeding at random	Average phenotype of offspring compared with midpoint of parents, if dominance is complete
1. $AA \times AA$	q^4	Equal
2. $AA \times Aa$	$4q^3(1-q)$	Equal
3. $AA \times aa$	$2q^2(1-q)^2$	Offspring higher by $w/2$
4. $Aa \times Aa$	$4q^2(1-q)^2$	Offspring lower by $w/4$
5. $Aa \times aa$	$4q(1-q)^3$	Equal
6. $aa \times aa$	$(1-q)^4$	Equal

The principle that offspring average midway between their parents, even though dominance is complete, is violated only by matings of types 3 and 4. In a population breeding at random, matings of type 4 are exactly twice as frequent as matings of type 3. The deviations of these two types of matings from the general rule exactly cancel each other. Close inbreeding will decrease the matings of type 3 more than those of type 4 (hence in part the decline which is a general consequence of inbreeding) while the crossing of distinctly unrelated lines will increase matings of type 3 much more than those of type 4. Other deviations from strictly random matings are of slight importance in altering the frequency of the different kinds of matings. Selection for the dominant diminishes matings of type 6 most and those of types 3 and 5 next. If the trait selected is influenced by many genes, such selection will have only a very faint tendency to alter the proportions of the types of matings, so far as one pair of genes is concerned.

Dominance does modify the consequences of *individual matings* slightly. If the parents are both phenotypic extremes in the same direction, their offspring will usually average a little nearer the mean of the race than the parents do. Thus if both parents are selected because they show the effects of an unusual number of dominant factors, they will have more than the normal proportion of gene pairs where the mating is of the $Aa \times Aa$ type and fewer matings of the $AA \times aa$ type. Conversely, if both parents are selected because they show the effects of few dominant factors, the opportunity for $Aa \times Aa$ matings will be reduced more than the opportunity for $AA \times aa$ matings.

Practically this effect will be slight and almost indistinguishable from the effect of random environmental variations which also lead to regression toward the mean of the race. (The "race" includes the interbreeding population which might in nature be a whole species or a geographically isolated portion of a species but in practical dairy cattle breeding would be the breed, since our pure breeding system isolates each breed from the rest of its species).

3. *The effects of environment.* Since the production of a cow depends upon the environment to which she is exposed as well as upon the genes she

has, any attempt to estimate whether her heredity was for high or low propuction will be subject to some error from mistaking the effects of environment for the effects of genes.

The larger the variation in environment to which the cows have been exposed, the larger will be the amount of error in estimating the cow's inheritance from her known production. Obviously, the ideal way to avoid this is to expose all cows to the same environment. It is equally obvious that this can never be done perfectly and cannot even be approximated when the comparison is between records made in herds under different management and at different ages.

(a) *Corrections to standard conditions.* The next best thing to having the records made under uniform environment is to estimate what each record would have been under standard conditions. Of course correction factors do not exactly allow for the effect which a difference in conditions had on all individual records. Perhaps it is true on the average that milking three times a day, instead of two, increases production twenty per cent, yet not all individual cows will respond exactly this much to the extra milking. A set of twice-a-day records corrected to a thrice-a-day basis will differ individually at least a little from the records which would have been obtained if these same cows had actually been milked three times a day, while every other environmental condition remained rigidly the same. Yet if the condition for which correction is being made is at all important, the use of a well-based correction factor to estimate what the record would have been under standard conditions, will remove much of the effects of differences in environment which would otherwise bias any conclusions to be drawn from the data. Such corrections should be used in spite of the fact that occasionally a "corrected" record will be more in error than if it had not been corrected at all.

Practical considerations limit the number of corrections which can be made. Ordinarily only a little accuracy would be gained by correcting for other than the most important circumstances such as age, times per day milked and (if such can be managed) a general estimate of the conditions of feeding and management. The preceding dry period may need to be taken into account if it was unusually short. Lactations incomplete through no fault of the cow or lactations terminated very early by recurrent pregnancy would need correction to standard length.

The choice of the conditions which shall be used as "standard" should be guided by the general principle that animals should be tested under conditions the same as those under which they are to be used. Thus the recent Holstein-Friesian decision to correct to thrice-a-day milking as a standard instead of four times is sound since few cows will be milked four times a day commercially while many are milked three times daily for purely commercial reasons. The standard conditions, including the ration fed, should

be good enough that few cows are seriously limited by those conditions. Beyond that level there is little use in forcing the cows. Indeed there is the certainty that some cows will respond to such forcing more than others without there being a corresponding difference in what they could produce under the commercial conditions for which after all they are being bred.

(b) *The effect of unknown differences in herd environment.* Cows tested in the same herd will tend to have been exposed to the same environment and management. If this environment is any better or any worse than is thought when the corrections for it are made, all the records from that herd will thereby be biased in the same direction. Increasing the number of records from that herd does not correct for this. This source of error is in all records and in general is more important the less we know about the management of the different herds.

This is perhaps the most difficult part of the problem which confronts one who attempts to rate large numbers of sires on the basis of published official records or C. T. A. records alone. A certain amount of information is gained by such estimates but one would often be mistaken in individual cases and the accuracy of the estimates could not rise to a very high level. Increasing the number of tested daughters beyond 3 or 4 under such conditions adds but little to the accuracy of the estimate of the sire's *genotype,* although it may add materially to the accuracy of an estimate of what other daughters *in that same herd* will produce.

(c) *The effect of random environment.* Random environment which affects one cow but not her stable mates (and much of which will be unknown even to the breeder himself) has as its principal effect (as in the case of dominance) a regression toward the mean of the breed.

The effects of random environment may be minimized by increasing the number of daughters included in the progeny test and by seeing that the records used are not selected records but are the records made nearest a given age or are selected by some other method not based on the magnitude of the record itself.

The effects of random environment on the record of any one cow are most effectively minimized by using an average of all her records, excluding only those *definitely known* to have been abnormal (as from abortion or other definite illness). Because of its effects on the standard deviations this averaging is not always permissible in statistical studies. That reason naturally has no bearing on individual selections made in breeding practice.

4. *Differences in the merit of the dams.* If each herd could be regarded as a random sample of the cows in the breed, the average merit of the herds would not be exactly the same, just as samples from the same source are not exactly alike, yet the differences would not be important. In such a condition and with the simplest assumptions about the genetic situation, the records of three daughters out of untested dams would furnish as much infor-

mation as the records of two daughters out of tested dams. With a more complicated genetic situation (as no doubt exists) the ratio would not be exactly this but the general principle would still be true that the errors introduced by the absence of the dams' records could be balanced by an increase (perhaps *about* a 50% increase) in the number of daughters tested.

But it seems certain that herds really do differ from each other more than if they were random samples of the breed. The error thus introduced into a sire index by neglecting the records of the dams of his daughters cannot be overcome by increasing the number of daughters tested. Instead it is a steady bias which tends, as the number of daughters increases, to stabilize itself not at zero but at a fixed proportion (depending on how the index is constructed) of the difference between the average merit of the dams in that herd and the average merit of the breed. Any index which does not take the records of the dams into account rests implicitly on the assumption that the dams are average cows of the breed in merit.

5. *The effect of "nicking."* Although we do not know how general this form of gene interaction is, we do know that its effect is to make estimates of the sire's breeding value less reliable than if all genes acted either in an additive or a multiplicative way to produce their effects, almost regardless of what other genes were already present. On the whole the effects of nicking will be similar to those of random environment and of dominance, but the misleading effects of nicking will not be as steadily overcome by increasing the number of offspring in the sample tested.

One more practical point about "nicking" does deserve mention. The more important it is, the more one would be anxious to continue to use a good bull on cows closely related to those with which he was mated when he produced the offspring which proved him. Any bull apparently proved poor by his first offspring but which because of excellent pedigree, appearance, or for any other reason was still thought worth continuing in use should be used on cows as unrelated as possible to those whose offspring apparently proved him to be a poor sire. If nicking is important the matter of line-breeding and staying within certain family lines is considerably more important than if nicking is really a rare and comparatively unimportant phenomenon.

6. *Number of daughters.* Each daughter receives from her sire a sample half of his inheritance. Since this is a sampling process, it may happen that no one daughter receives from her sire a sample which is exactly typical of him. As the number of daughters is increased, the average of what they have received from their sire corresponds more and more closely to being exactly equal to half the genes he had. This follows the well-known laws of random sampling (provided all daughters or at least a truly random sample of them are tested without selection). The error in estimating the sire's genotype from a knowledge of what he has transmitted to his daugh-

ters can be reduced to an unimportant amount by increasing the number of daughters tested.

The error from Mendelian sampling is such that (if it alone is considered) one daughter is as accurate an indication of a bull's worth as either his dam or his sire is. Three daughters are as accurate as full knowledge of both his sire and dam. More than three daughters give more information than could possibly come from the completest kind of study of his pedigree.

Increasing the number of daughters decreases the error from random environment as effectively as it decreases the errors from the sampling nature of inheritance.

Increasing the number of daughters decreases the error from dominance and from "nicking" but not quite as regularly and uniformly (especially with the latter) as in the case of inheritance sampling.

Increasing the number of daughters does *not* decrease the error from unknown or uncorrected differences in herd environment, or from differences in the average merit of the dams.

Therefore the answer to the question of how many daughters are necessary to prove a sire depends upon how sure of his "proof" one wants to be and how much can be gained by testing more daughters. If the herd environment or the average merit of the dams are important and have not been taken into account correctly, the accuracy of the sire rating will remain low under any circumstances, and not much is gained by increasing the number of tested daughters past three or four. On the other hand, if herd environment and average merit of the dams are correctly discounted and if random environment is important, the sire rating may be considerably increased in accuracy by increasing the number of daughters even past eight or ten. Five is rather widely used as a minimum number where the dams' records are also taken into account and this seems to the writer worth adopting to avoid confusion wherever a formal definition of a minimum must be made. Increasing the number of daughters never detracts from the accuracy of the sire estimate and under some conditions may increase it materially. Hence such an increase is always to be desired in individual cases. In the present state of our knowledge it seems to the writer undesirable to *publish* any sire index based on fewer than five daughters (more than that if the dams are not taken into account). Nevertheless even the first daughter provides at least a faint indication of a sire's worth.

7. *Multiplicative and additive factors.* The three kinds of dairy records, milk produced, fat produced and test, cannot be independent. One is the product of the other two. But which one? The "Mount Hope Index" expresses the view that milk produced and test are independent. The bulk of the evidence tends more toward the energy basis of measuring yield

as advocated by Gaines and co-workers at the Illinois Station. According to this view the inherited differences are differences in the rate at which the cow can transform energy. If the energy appears in the form of fat it automatically cannot appear as solids not fat. Other inherited (and environmental) factors determine whether the test shall be high or low.

It is possible that neither extreme view is absolutely correct. The author's tentative solution of the problem (admittedly imperfect but usable) is to regard the total fat and the test as independent, with the amount of milk being a function of those two. This is almost the same as the energy yield basis since most of the variation in energy yield is a result of variation in the fat yield.

If all factors affecting test, milk and fat were strictly multiplicative in their action the difficulty could be avoided by using logarithms instead of actual numbers for the observed tests and yields. The index would come out practically the same regardless of whether it was figured for test, milk yield or fat yield. Since most people are unfamiliar with logarithms and it is unlikely that *all* these relations are multiplicative, it seems best to apply the index to the two kinds of records which are most likely to be independent and to figure the third from the two resulting indexes. Those who use "fat-corrected-milk" would naturally apply the index to those figures and calculate a separate index for test if they were interested in that.

PROPOSED INDEXES

Space forbids a detailed review of any but the most satisfactory or widely publicized of the indexes so far proposed. No one is entirely satisfactory and yet the weaknesses of one are not exactly the same as the weaknesses of another. With one exception, all are based on the daughter average as a starting point. They differ in the use they make of the increase or decrease of daughters over dams. The exception is the proposal to rate sires solely on the increase or decrease of their daughters over the dams. That proposal has so many theoretical and practical unsoundnesses that it no longer seems worth discussion.

The others may all be expressed in the equation: Sire index = Daughter average + k (Daughters' average minus Dams' average). The indexes differ in the value they assign to k.

1. *The daughter average.* When k is zero, the index becomes simply the daughter average. This is theoretically correct[1] if one wishes to predict the performance of future daughters out of the *same kind of cows* and reared and tested under the *same* herd environment as the daughters whose production is already known. This is just like any other case in which an experiment is repeated. The most probable result is the same as that of the

[1] Wright, Sewall. On the evaluation of dairy sires. Proc. Amer. Soc. An. Prod. 1931: 71–78. 1932.

first experiment. Because these conditions are so largely fulfilled in actual data, those who have sought to compare from actual data the predicting value of various indexes have in general obtained favorable results with the daughter average as compared with the various indexes against which they have tested it.

The special weakness of the daughter average as a sire index is that it makes no allowance for differences in the merit of the cows to which different bulls are bred. This has two consequences. First, the error thus introduced into a sire estimate tends toward a constant value instead of tending toward zero as the number of tested daughters increases. Second, even if the dams were random samples of their breed, something like fifty per cent more tested daughters out of untested dams would be required for the same degree of accuracy as if the dams had been tested too.

Errors due to unknown or improperly corrected herd environment are relatively larger in the daughter average than in those indexes which also take into account the increase or decrease of daughters over dams tested under similar conditions.

In addition to its simplicity the daughter average has the advantage that it utilizes the information about all the daughters of a bull regardless of whether their dams were tested. Moreover it is harder to "fake" by selection of the records used than is an index involving a comparison of daughters and dams.

The daughter average will necessarily be less variable than the actual records of the cows. This follows the well-known statistical relation between the standard deviation of an average and the standard deviation of its constituents. Where

$$A = \frac{X_1 + X_2 + \cdots + X_n}{n},$$

and ${}^{\sigma}X_1 = {}^{\sigma}X_2 = {}^{\sigma}X_3 = \cdots = {}^{\sigma}X_n$ approximately, and

$$r_{X_1X_2} = r_{X_1X_3} = r_{X_2X_3} = \cdots = r_{X_mX_n}$$

approximately, this may be expressed as follows:

$${}^{\sigma}A = {}^{\sigma}X\sqrt{\frac{1 + (n-1)\,{}^{r}XX_n}{n}}$$

With a correlation of + .30 between paternal half sisters (about what has been found in official records), ${}^{\sigma}A$ when n is 5 or more, would be only about 5/9 to 2/3 as large as ${}^{\sigma}X$, the exact fraction depending on the size of n. With a smaller correlation than + .30 the decrease in the variability of the average would be even more extreme.

Thus a daughter average of 800 pounds of fat for a sire may be as rare and hard to obtain as an individual record of 1000 pounds of fat for a cow. The use of the daughter average as an index will require some kind of a mental translation to allow for the smaller variability of the sire index

when comparing bulls with cows. This is not a defect in principle but it is an inconvenience whenever it is necessary to compare the merits of female with those of male ancestors. This diminished variability is more extreme with the daughter average than with the indexes which also take into account the difference between daughters and dams.

LaMaster's proposal[2] to index bulls by the percentage which the daughters' production is of the average production of all cows tested in the same classes differs from the daughter average only in that he avoids the necessity of correcting for age, and for the management conditions by assuming that those things are equal for all cows grouped in any one class. The dams' records might also be expressed as percentages of the breed average, thus making it possible to consider increase or decrease of daughters, too. However, LaMaster's "production factor" does not combine in one index the daughter performance and its increase or decrease over dam's performance. LaMaster's "production factor" is subject to the objection that the value of the sires would not without an additional computation be expressed in pounds of milk or fat as the production records of the female ancestors usually are, although this is only a minor inconvenience in its application and does not invalidate its principles which are the same as those of the daughter average. La Master's "production factor" has the practically important advantage that its expression as a percentage gives the reader a quick picture of whether the index is relatively high or low without it being necessary for him to carry in mind actual class averages or measures of variability.

2. *The equal parent index.* Since the offspring tend to average midway between the parents, inheriting equally from them both, the simplest index which would include those facts is to add to the daughter average the increase of the daughters over their dams. That is, k in the general equation has a value of one. This is the index proposed by Nils Hansson in Sweden nearly twenty years ago. T. E. Woodward used it in 1922 on Guernsey fat records. It is the same index applied by Yapp in 1924 to "fat-corrected milk." The much publicized "Mount Hope Index" becomes simply this when it is freed from a misconception about the effects of dominance. (The index at present used by the Holstein-Friesian Association in its Herd Improvement Registry data under the name of "Mount Hope Index" has in fact been freed from this misconception about the consequences of dominance which distinguished the original Mount Hope Index from the general expression of this same idea.) That the offspring average midway between the parents is fundamentally the same idea as that introduced into genetic literature many years ago by J. Schmidt of the Carlsberg Laboratory under the term "diallel crossing," except that Schmidt's material permitted mat-

[2] LaMaster, J. P. Production factors applied to Jerseys. The Jersey Bulletin 51 (22): 763–764. 1932.

ing each of several different males to the same females. Because the females were mated to each of the males, he avoided the necessity of assuming anything about the genotypic values of the females. His findings were that the genotypic values of the sires differed by twice as much as the difference between the phenotypic averages of their progeny. R. A. Fisher in his book on "The Genetical Theory of Natural Selection" endorses as a sound general principle this finding from the experiments on diallel crossing. Wright (*loc. cit.*) shows that this index is a statistically valid means of estimating the sire's genotype for production but subject of course to a sampling error. The idea is foreshadowed in much of Galton's work on human inheritance where he studied the "parental mid-point," although most of his studies were on traits which could be manifested by both sexes and therefore he was not in much need of an actual "index." The idea of the equal parent index is such a simple one that it is probably as impossible as it is unnecessary to trace its origin or to couple it with the name of any one man. It seems to the writer that the term "equal parent index" is simple enough, accurately descriptive enough and free enough from implications about priority that this term might well come into general use. (Since this was written Professor V. A. Rice has in several articles urged the use of the term "intermediate index" which also seems to the writer accurately descriptive and free from implications about priority. Probably the name used is not important except that confusion should be avoided. Presumably the name ultimately in common use will be decided by the "survival of the fittest"!)

The advantage of the equal parent index over the daughter average is that the former removes the errors (except the effects of random environment on the dams' records) arising from differences in the productiveness of the cows to which each bull was bred. Also the range of the equal parent index is more nearly (though perhaps not exactly) like that of cows' actual records. This makes translation from actual records of cows to indexes of bulls and back again in pedigree study less necessary.

The weaknesses of the equal parent index are (1) that it is more easily "faked" by selecting the lowest records of the dams and the highest record of the daughters in case the one computing it deliberately seeks to deceive, (2) that if the herd environment of dams is different from that of the daughters, and if corrections for that are not entirely accurate, the effects are put down as effects of the sire's genotype and (3) that it doesn't use information about tested daughters out of dams which for one reason or another were not tested.

Weakness No. 1 might become important if the index should come to have much commercial value but of course does not exist for a man who is interested in finding out for his own use how good his own bull is. No. 2 will not often be an important source of error where the records were made

in the same herd, but the possibility should always be kept in mind that it may have been important in any one case. If the daughters' herd environment is correlated with that of the dams as highly as +.25, herd environment will be relatively a less serious source of error in the equal parent index than in the daughter average. If much culling of cows on the basis of their production records has been practiced, there will be some tendency for the dams to be only the selected survivors of their generation, while the daughters represent their whole generation. This will introduce a slight bias because (on account of this culling) the dams' records will average a little above the dams' genotypes, even when the records are fairly selected, whereas daughters' records will not be thus biased. As for objection No. 3, there would probably be little error introduced by assuming that the untested dams were equal in merit to the tested ones. Whatever *bias* there is in this assumption would tend to give the sire a lower index since the untested dams might be expected on the whole to average a little lower than the tested ones if they differ systematically at all. Those who may think that such an assumption (*i.e.*, that the untested dams would average the same as the tested ones) is a very rash one may be reminded that the use of the daughter average as an index rests upon the assumption that each group of dams is an average sample of the cows of the breed.

3. *Norton's index.* H. W. Norton, Jr., has tentatively suggested an index outwardly similar to the equal parent index, except that it takes into account the average amount of regression toward the mean of the breed which has occurred in the past, without bothering to inquire into the causes of that regression. Mr. Norton has calculated from a large number of Holstein-Friesian Advanced Registry records the average production by daughters out of cows of each level of production. This he calls the "expectancy for daughters" from dams of such a level. His index differs from the equal parent index only in that he substitutes this "expectancy" in place of the average record of the dams. Thus if a sire is mated to dams averaging 850 pounds, and produces daughters which average 810 pounds, Mr. Norton would turn to his expectancy table which shows that, in the breed as a whole, dams averaging 850 pounds have produced daughters averaging 718 pounds. This would be the "expectancy" for daughters from the particular group of dams. This particular sire's daughters exceeded their "expectancy" by 92 pounds. Adding this difference to the average of the daughters would get for this bull an index of 902 pounds.

This proposal has the merit of discounting the regression actually observed, so that in this respect the index figure will be directly comparable with cows' records. Likewise it has the advantage (for teaching purposes at least) that to most people it will seem to be based less on theory and more on actual data with a minimum amount of deduction.

The "expectancy" figure corresponds closely, except for a little curvilinearity at the extremes, to the equation: Expectancy $= \frac{\text{Dam}}{3} + \frac{2}{3}$ breed average. Thus, Sire index = Daughter + $\frac{1}{3}$ (Daughter-Dam) + $\frac{2}{3}$ Daughter-breed average). This index is therefore a mixture of about one-third equal parent index and two-thirds daughter average, the latter having had its range expanded so that it would be about the same as the range of cows' actual records. Apparently this index does not discount the error from genuine herd differentiation in the dams' merits as completely as the equal parent index does. Also it seems more vulnerable to errors from the daughter's herd environment being better (or worse) than is thought when their records are being corrected to standard conditions. On the other hand, because it takes into account the actual regression, including whatever there may be from dominance, nicking, random environment, and selection of dams, it probably is a little fairer to unusually good bulls mated to unusually good cows and to unusually poor bulls mated to poor cows, giving them in both cases an index rather fairly comparable with the actual records of cows. It might be especially suitable for use with official records where there has been considerable selection of cows to be tested, although no index can discount completely the effects of such selection.

An index of this type may deserve further study. But before such an index could be applied to other data than Holstein-Friesian Advanced Registry it would be necessary to prepare similar "expectancy" tables for each population concerned.

4. *Indexes with values of less than one for k.* Studies af actual data in an attempt to derive from them empirically an index which will predict with the minimum standard error of estimate the breeding value of a sire, may be expected generally to result in a formula which is a compromise between the daughter average and the equal parent index, that is, with k having a positive value between zero and 1.0. For example Turner's study of Guernsey sires (Missouri Research Bulletin 79, especially page 37) finds a value for k of 3/17. This general result is to be expected because future daughters of a bull would usually be reared in the same herd and out of the same kind of dams as his first daughters. The exact point of compromise (that is, the exact value of k) would largely depend upon the extent to which the dams of the early daughters of a sire really differed in merit from the dams of the later daughters, and on the extent to which the first daughters and the later daughters were in the same herd.

5. *Prospects of deriving a satisfactory index by simple statistical treatment of existing data.* There seems to be no prospect of settling the question of which index is the most accurate by appealing directly to actual data such as exist in official records or C. T. A. records. It seems impossi-

ble to exclude from such data all the effects of selection on the dams and daughters tested, the records used, and which sires are given opportunity to sire large numbers of daughters. More important still, such data are affected by the differentiation from herd to herd both in management and in the average merit of the cows. Even in single large herds the management and average merit of the cows vary from time to time.

The complexity of the problem is shown by figure 1, which is a graphic scheme for showing why correlations may be high or low under different circumstances. The square of a correlation coefficient measures the portion of the variance in one variable which disappears when the other is held constant. Thus squared correlation coefficients between an index and the sire's genotype (the thing it is intended to measure) may be pictured as fractions of which the denominator is all the variance in the index for a large population of bulls and the numerator is that portion of the variance which genuinely results from differences in the bulls' genotypes. Fraction

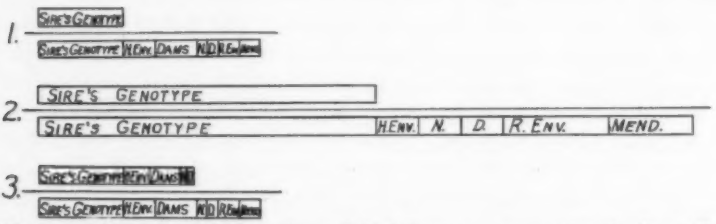


FIG. 1. Scheme for showing why certain indexes are more accurate than others. Each squared correlation is represented as a fraction, the denominator being the total variance in the index and the numerator being that portion of the variance arising from the thing which is to be predicted.—1. The squared correlation between the daughter average and the sire's genotype. 2. The squared correlation between the equal parent index and the sire's genotype. 3. The squared correlation between the average of a sire's first daughters and the average of his later daughters. Compare 1 and 2 or 1 and 3.

No. 1 represents this for the correlation between sire's genotype and daughter average, No. 2 represents the same thing for the equal parent index and No. 3 shows why the correlation between a sire's first daughters and his later daughters is so high in most studies of official records and C. T. A. data. The proportions of the different segments of the denominator are but rough approximations, the data to measure those proportions being so lacking in some cases that the proportions pictured scarcely deserve to be called more than guesses. The abbreviations are:

H.Env. = Herd environment or conditions of management which differ from herd to herd but which affect alike all the cows in the herd. So far as those effects are removed by the use of correction factors, this element would disappear from the

problem. Hence it will be more important in some groups of data than in others.

Dams = Differences in the average merit of the dams to which the sire was bred.

N. = Effects of complex gene interaction or "nicking."

D. = Effects of dominance.

R.Env. = Random environment which affects one cow but not her stable mates and is not removed by appropriate correction factors.

Mend. = Effects of Mendelism or chance in the sampling of the parental inheritance when the gametes are produced.

Comparing No. 1 and No. 2, the contribution of the sire's genotype to both numerator and denominator is much increased in the latter, in accordance with the principle from diallel crossing that the difference between the offspring is only half the difference between the sires' genotypes if the groups of dams are of equal merit. Since these fractions represent squares, the denominator of No. 2 is four times as long as that of No. 1 in all its constituents except the merit of the dams, which does not appear in No. 2 at all, and the herd environment which, if identical for daughters and dams, will be of the same size in No. 1 and No. 2. If herd environment is not the same for daughters and dams, it will contribute more to No. 2 than to No. 1, though not four times as much if the correlation between daughters' herd environment and dams' herd environment is as high as +.25. The absolute size of random environment is increased about five times in No. 2. In comparing No. 2 with No. 1, the range in absolute units is greatly increased, the effect of differences in the average merit of the dams is eliminated and relatively the effects of inadequately corrected herd environment become less, while the effects of random environment become a little larger.

Increasing the number of daughters tested decreases R.Env. and Mend. steadily in proportion to the number. N. and D. are also decreased by this but not so regularly nor effectively. H.Env. and Dams are not thus reduced. Figure 1 is drawn according to the writer's estimate of the proportion of variance from each source in indexes based upon about 5 to 8 daughters and on Advanced registry data where no corrections could be made except for age, times milked per day, and date of beginning of next pregnancy.

No. 3 shows graphically why the first daughters of a sire are usually so closely correlated with his subsequent daughters. Much of H.Env. and Dams and even some of the N. and D. is repeated in the numerator. The numerator is therefore far from representing the sire's genotype alone.

It is the writer's present opinion that the most profitable research work which can be done with official records or similar data at the present stage of our knowledge is to measure more accurately than in the rough approximations shown in figure 1, the relative importance of the different causes of

variance in production records. Perhaps if such an analysis is carried very far it may be advisable to sub-divide some of these terms or even to add terms for cross correlation between them as, for example, if sires with the best genotypes tend to be used in those herds where environment is best and *vice versa*. These diagrams may appear complicated but they must be simplicity itself compared to an accurate detailed picture of all the interactions of genes, environment and breeders' practices which together cause a given set of actual records to be what they are.

In this connection, critical reference should be made to two fallacies which (by unintentional inference, of course) have come into the literature on this subject largely as a result of the work done by those who sought to check the accuracy of indexes by a direct appeal to the official records.

The first is the inference that the daughter's record is in some way a "genotypic" measure of the sire whereas the dam's record is a "phenotypic" expression of the dam's genotype and therefore not so reliable. If daughters' and dams' records are both used without selection, the daughter's record of course stands in exactly the same relation to her genotype as the dam's record stands to the dam's genotype. In estimating the dam's genotype from her record there is always the possibility of error from mistaking the effects of unknown or inadequately corrected environment for the effects of genes. In estimating the sire's genotype from a daughter's record there is exactly the same possibility of error plus the additional sampling error of Mendelian inheritance whereby this daughter may happen to have received better (or worse) inheritance from him than he would have transmitted to an infinite number of daughters. The only respect in which the daughter average can become more "genotypic" than the dam's record is the purely statistical fact that increasing the number of daughters decreases the errors from random environment and from Mendelian inheritance. If they are decreased enough by having many daughters in the average, the combined error from them may become less than the error from random environment in a dam's record. But if the number of dams is increased also, the error from random environment diminishes there, too. For example if we have 10 tested daughters out of 10 tested dams, the average of the dams' records is a more accurate index of their average genotype for production than the daughter average is of the sire's genotype because the latter still contains at least a small amount of Mendelian sampling error not in the former. Most of the confusion on this subject arises out of failure to distinguish clearly between fundamental biological or statistical relations of single records and the purely statistical consequences of averaging these records in various ways.

The second fallacy arises when the cows mated to one bull are divided into groups on the basis of their known records and the average production

of the daughters of each group is calculated. This is legitimate when each cow is considered as an individual and one wishes to find the regression of individual daughters toward the mean of the breed. It is not legitimate to infer that this is the same situation as if one bull were mated to three separate herds of the productive levels represented by these dam's averages. The manner of division into the three groups insures that the effects of poor random environment will be much more prominent in the low group and that there will be many more effects of good random environment in the high group than if the cows had been assembled on any other basis than the *ex post facto* knowledge of their previous records. Much of the random environment is thus turned into biased environment. Naturally the regression toward the mean of the herd is extreme. If one really wished to pursue this sort of investigation far the legitimate procedure would be to make the division as is done, then to discard the dams' records on the basis of which the division was made, and then to use as the productivity of the three groups of dams, the average of their records in the next lactation of each. These averages of following lactations would be legitimately comparable with separate herds of high, medium and low production. Naturally data suitable for such a study and free from pronounced selection are not available now, although perhaps they may be when the Herd Improvement Tests have been in operation longer.

The most efficient statistical method for exploring the average relation between dam and daughter among the daughters of a single sire is to calculate a daughter-dam correlation on the whole population, then correct that for heterogeneity on account of the different sires represented.[3] The calculation is easy but the interpretation is difficult because when the sire is "held constant," so, too, is the herd environment and part of the variance in dam's merit, thus leaving random environment a relatively important rôle to play. It therefore seems impossible to assess the sire's importance by comparing the daughter-dam correlation in the breed as a whole with the average daughter-dam correlation among the daughters of individual sires, since so many other things besides the sire differ in the two correlations.

To the extent that the investigations of actual records purport to show that the dams' records are unimportant, they have succeeded only in showing that those records (and the daughters' records, too!) are importantly

[3] Richey, F. D. and Willier, J. G. A statistical study of the relation between seed-ear characters and productiveness in corn. U. S. D. A. Department Bulletin 1321. 1925. See especially pages 7 and 8. The method here given would not take into account the degrees of freedom lost by treating each sire as a unit but that is important only in establishing the statistical significance of the resulting correlations, and may be had from Fisher's method of the "analysis of co-variance" (Statistical Methods for Research Workers, 4th edition).

affected by environment. To the extent that in some of these investigations the sire seems more important than the dams, it is only that the sire is being credited with many of the effects of herd environment and with many of the herd differences in the dam's merit too! No doubt there is a smattering of sex-linkage in the problem, too; but that can hardly be large enough to be detected in view of the magnitude of the other sources of error in the present data.

PRACTICAL CONSIDERATIONS

1. The index should be as simple as is consistent with accuracy and usefulness. The daughter average is the simplest of the usable indexes but the equal parent index is almost as simple and is considerably more accurate if herds differ much in the average merits of their cows.

2. For convenience in use the bull index should be expressed in the same terms and with nearly the same range or standard deviation as the actual records of the cows, so that in comparing bulls and cows there would be little need for a mental translation from one kind of unit to another. The daughter average has a much narrower range than the cows' records and narrower than any of the other usable indexes. This could be overcome roughly (if it were thought worth the effort) by increasing the daughter average by some fifty to seventy per cent and subtracting the breed average from that figure. The range of the equal parent index would probably not be very different from the range of the actual records, although that would vary slightly with the number of daughters tested as well as with the correlations between herd mates, between half sisters and between daughter and dam in the data used.

3. The index should be available on as many bulls as possible and for each bull it is desirable to use all possible information. This is the strongest feature of the daughter average as an index. There should be a place for using information about the sire's sisters, dam and other female collateral relatives and ancestors. None of the present indexes do that.

4. The records used should be absolutely unselected or at least selected by some method which is not at all influenced by the magnitude of the records. This applies both to the selection of daughters to be tested and to the selection of records used when a cow or her daughter have more than one record. One of the strong points of the daughter average is that it is more difficult to load the dice by selecting high records in one place and low records in another. The plans with the least bias seem to be the use of (1) either the very first record which either animal has made, (2) the record made nearest maturity regardless of the magnitude of that record, or (3) records made in the same year, the choice of years used to be based upon one of the preceding plans and not to be influenced at all by the magnitude of either record. The first rule has the advantage of making the

final index figure available while the sire is younger than under the other procedure. The use of the record nearest maturity has the advantage of avoiding some of the individual errors in age correction factors but may contain errors from some permanent damages which may have been done to the producing ability of the cow while she was still young. For example, one or more quarters of her udder may have been destroyed by infection and this would be unfairly charged against her hereditary worth unless another correction were made for that fact. The third plan goes far toward keeping differences in herd environment from affecting the daughter-dam differences.

If indexes become popular and acquire any considerable commercial value, the matter of insuring that the records used shall not be selected by some biased methods, will become quite important. This will be more important if the index eventually adopted is one that takes into account the dam's record than if it is the daughter average alone.

5. *Index recommended.* The writer recommends the equal parent index for general use since it most nearly complies with practical considerations and is soundest in principle. Its greatest vulnerability is in the possibility that daughters and dams may not have been tested under the same conditions and that it may be distorted so much by deliberately biased selection of the records used. A minor weakness is its failure to utilize information about daughters out of untested dams. Information about daughters of untested dams can be used (but with somewhat less confidence) by assuming that their dams would have averaged the same as the tested dams. The equal parent index can be applied to any other characteristic which can be measured or scored with usable accuracy in the cows or their daughters.

This is not to say that the daughter average is useless as an index. Far from it. The daughter average is the first step on which the usable sire indexes are all built. But it neglects differences in the merit of the dams and is rather sharply affected by herd environment. There seems no reason for not correcting those two defects wherever the increase or decrease of daughters over dams is known so that such a correction can be made.

SUMMARY

The genetic principles affecting the validity of bull indexes are reviewed.

All the indexes accurate enough to deserve further consideration start with the average production of the daughters as a basis. They differ only in the use and emphasis which they make of the difference between daughters and dams.

Differences in herd environment affect all indexes since they enter into the daughter average which is the base of all indexes. They are less important in the equal parent index than in the daughter average if the cor-

relation between herd environment of daughter and of dam is as high as .25.

Differences in the average genetic merit of the cows to which the bull was mated are neglected in the daughter average but are discounted in the equal parent index.

Errors due to random environment and to the part played by chance in inheritance are reduced by increasing the number of daughters tested. Errors due to dominance and to "nicking" are also thus reduced but not so effectively. Errors due to herd environment and to differences in the average merit of the dams are biased and do not trend toward zero as the number of daughters tested is increased.

No index will give infallible results. The sources of error cannot be absolutely eliminated. All that can be done is to minimize them as much as possible. The more one knows about the conditions under which the records were made, the more he can reduce these errors. Even if all other possibilities of error were overcome, there would still remain the sampling error intrinsic in the Mendelian nature of inheritance.

The writer recommends the equal parent index (the daughter average plus the increase of daughters over dams) as soundest in principle, simple enough for field use, freest from systematic error, and having a range not very different from that of the actual records of cows.

LACTATION IN A BARREN HEIFER[1]

IVAR JOHANSSON AND M. H. KNUDSEN
Department of Genetics, University of Wisconsin, Madison

Numerous cases of the production of milk by virgin or non-fecund females of different species of domesticated mammals have been reported. A comprehensive summary of the German literature on this subject is published by Spann (3). With reference to dairy cattle the English literature is summarized by Turner (4) in connection with the report on an experimental study of the initiation of milk secretion. A literature survey, as an introduction to the present report on a case of lactation in a barren heifer, would therefore be superfluous. It seems justified, however, to put the case on record, since we have more complete information on the yield and composition of the milk than in any similar case reported before.

In the cross-breeding herd of the Genetics Department of the University of Wisconsin a barren heifer (No. 10A) started to produce milk and continued to do so for 630 days. She was an F_1 from a purebred Jersey sire (King Sapphos' Climax, 98,308) and a purebred Aberdeen-Angus cow (Bonnie Jean Pine 4th, 147,572), and was born January 30, 1914. She was polled and black, as might be expected from her parentage, and developed a strong body, somewhat long-legged and masculine in type. At the age of three years she weighed 1266 lbs.

The records on the sexual behavior of this heifer are not complete, but the data on hand are presented because of their probable significance in relation to the initiation and yield of secretion. She was bred for the first time March 23, 1916, at an age of two years and two months, but the preceding estrus periods are not recorded. Before the end of November, 1916, she was bred fifteen times at irregular intervals. Apparently the normal regularity of the estrous cycle was disturbed. The intervals between matings varied from one to twenty-five days. In October, 1916, she was examined by a veterinarian, who believed he was able to open up the constricted cervix. During December, 1916, and January, 1917, no matings occurred and heat was not recorded, but in February matings started again. In April, 1917, the heifer was reported to be almost constantly in heat, and she was mated four times during that month. At this time she had developed rather pronounced characteristics of nymphomania. Breeding was now discontinued until January, 1918. From then on she was mated once

Received for publication December 14, 1932.

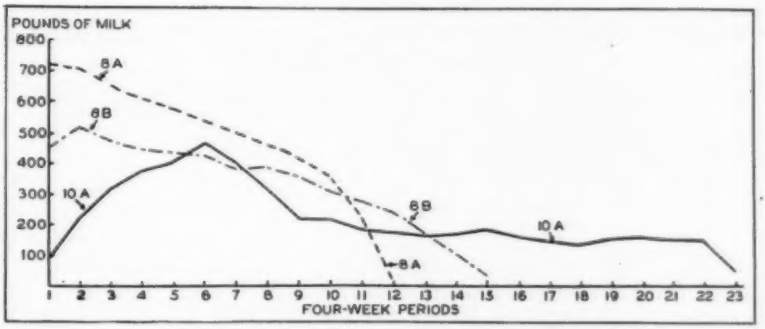
[1] Contribution from the Department of Genetics, Wisconsin Agricultural Experiment Station, Madison, Wis. Paper No. 144. Published with the approval of the Director.

or twice almost every month during the year. In December, 1917, and May, 1918, she reacted to the contagious abortion test. In February, 1919, she was again examined by a veterinarian, who found the cervix very constricted. Artificial insemination was accordingly attempted, but it was unsuccessful and it is probable the seminal fluid did not get into the uterus. The heifer was slaughtered in June, 1920, at which time she was very fat. At the post-mortem examination of the genital organs the right ovary was found to contain two very large cysts, the left ovary appeared normal but was a little congested with blood. No opening at all could be found through the cervix. At the vaginal end there was a blind passage but at the uterine end the cervix was entirely closed by a cartilage. Probably there had never been any communication between the vagina and the uterus. The uterus was thin-walled and contained two to three pints of a watery fluid.

In the summer and fall of 1916, 10A was paddocked together with other heifers and calves, and it was observed that some of the animals had acquired the habit of sucking each other. The udder of 10A enlarged, and it was quite evident that the calves were getting milk. On January 13, 1917, she was separated from the other animals and milked by hand, at which time she gave five pounds of milk. The following day she yielded, at two milkings, three pounds of milk. The next three days she was milked only once a day, and on the 18th no milking was done; after this date she was milked regularly twice daily until September 22, 1918, when she began to dry off. In 630 days she produced 5011.9 pounds of milk with an average fat per cent of 4.39. The total butterfat production during the lactation was 220 pounds. The Babcock test was made once a week on composite samples taken at each milking.

The daily yield of milk increased gradually after the beginning of regular hand milking and reached its maximum, 18.7 pounds, June 24, 1917, after which the yield declined. At the end of August the heifer was off feed for a few days, due to digestive disturbances, and the yield dropped further. When the appetite was regained the milk yield increased somewhat again, and she continued to give five to seven pounds of milk daily until September, 1918.

In the accompanying figure the lactation curves are presented for the non-breeder 10A, and for the first lactations of two of her half-sisters on the sire's side, 8A and 8B, which are also F_1 crossbreds, from an Aberdeen-Angus dam and the same Jersey sire. The heifer 8A freshened at the age of two years and eight months and was in milk for 324 days. The whole calving interval was 327 days. The other heifer, 8B, was two years and four months old at the time of freshening and gave milk for 411 days. Her calving interval was 413 days. The lactation curve for each individual is obtained by plotting the milk yield for successive four-week periods. There is a considerable difference between the shape of the curves for the lactation



of the barren heifer 10A and for the lactation after normal pregnancy of her two half-sisters. For 8A and 8B the lactation is at its maximum during the first two months after parturition, whereas for 10A the daily yield of milk starts low and increases steadily for about six months. The maximum daily yield reaches almost the same level for 10A as for 8B, although considerably later. This may be considered as a significant difference in the shape of the lactation curves for 10A and her two half-sisters. 10A continued to give a small daily yield for a long time after the first decline in production, but this would be expected when no pregnancy interfered with the lactation.

It may also be significant that in the case of 10A the increase in milk production during the first six months of hand milking coincides with the most intense sexual activity observed in this animal. About two months preceding the maximum daily yield she was reported to be almost constantly in heat. The records were also examined in order to find if there were any correlation between each heat period and the milk yield in the days immediately preceding and following heat, but no clear indication of such relationship was found.

At the time when 10A was in milk chemical analyses of the milk from each cow in the crossbreeding herd were made once in every four-week period. Samples were taken at each milking during three consecutive days in the second week of the period, and the composite sample was analyzed by the Department of Agricultural Chemistry. A part of the sample was separated, the cream churned, and the iodine (Hübl) number and Reichert-Meissl number of the butterfat were determined. The analyses were made according to the methods adopted by the Association of Official Agricultural Chemists. There are 23 sets of such analyses of the milk of 10A during her 630 days of lactation. The non-weighted averages of these analyses are presented in table 1.

It is not known how long 10A had been sucked by her mates before hand milking was begun but most probably this had been taking place for several

TABLE 1

Milk analyses for 10A, and for three other F_1 cows of the Aberdeen-Angus × Jersey cross during their first lactation periods

	10A		AVERAGE OF THE FIRST 6 FOUR-WEEK PERIODS OF THE LACTATION			
	Analysis 2nd week of lactation	Average 23 analyses	10A	8A	8B	7A
	1	2	3	4	5	6
Specific gravity	1.0350	1.0232	1.0342	1.0339	1.0334	1.033
Total solids	14.26	13.24	13.99	13.36	12.33	13.69
Fat	4.63	4.20	4.35	4.37	3.96	4.88
Total protein	4.38	3.90	3.93	3.56	3.40	3.59
Casein	3.52	3.07	3.06	2.70	2.63	2.84
Ash	0.74	0.70	0.75	0.75	0.77	0.74
Milk sugar	4.37	4.75	5.08	4.98	4.63	4.49
Iodine number of butterfat (Hübl)	43.90	41.29	49.89	39.43	38.09	31.08
Reichert-Meissl number of butterfat	28.49	25.89	28.12	29.08	28.29	28.77

weeks, or perhaps months. The percentages of fat and protein were both a little higher at the time the first analysis was made than later on, but the difference is small. In columns three to six of the table the milk analyses for the first six four-week periods of the lactations of 10A, 8A, 8B and 7A (an F_1 animal from Angus sire and Jersey dam) are presented for comparison. The last cow, 7A, is included because she calved in November and was therefore during the first six months of the lactation fed a ration comparable to that of 10A. Of the others, 8B also freshened in the fall, whereas 8A dropped her first calf in May.

The composition of the milk of 10A can well be considered to fall within the range of normal variation of cow's milk, and there does not seem to be any significant difference between her milk and that of the other cows, at least not as far as protein, fat, milk sugar and ash are concerned. The iodine number of the butterfat of the milk from 10A is very high during the first six months of the lactation when the daily yield was increasing. It is a well known fact that the amount of unsaturated fatty acids in the butterfat is influenced to a high degree by the nature of the feed consumed. Green pasture, particularly, produces butterfat with a high olein content and consequently a high iodine number. During the time when the heifer 10A produced butterfat with the highest iodine number she was not on pasture, however, but fed hay, silage and concentrates. No complete records were kept of the quantity of each feed consumed. Towards the end of the lactation the iodine number of the butterfat was gradually decreasing, the average for three determinations during the last four-week periods of the lactation being only 29.31.

After 10A had been dry from October 4, 1918, to May 14, 1919, it was decided to attempt to get her in milk again, and she was accordingly milked by hand twice daily. This was continued until June 30, but the milk obtained was only about a teaspoonful at each milking. The heifer was therefore turned on pasture, and the milkings were discontinued for five days. On July 5, 10A was taken off pasture, and a calf was allowed to suck her in the daytime. She was milked by hand each morning. The attempts to bring her into milk were not successful, however, and were therefore discontinued.

Becker and McGillard (1) have reported a case of "non-fecund" lactation in a cow, which after three normal lactations developed cystic ovaries, and did not become pregnant again for a considerable length of time. After having been dry for ten and a half months, one quarter of the udder became infected and was therefore milked out daily. The secretion of milk increased, and later the cow was put on regular milking twice a day. In 399 days she produced 5199.1 pounds of milk with 3.41 per cent of butterfat. During the first sixty days of milking the daily yield increased, and thereafter decreased very slowly. The "non-fecund" lactation curve was very flat compared to the curves of the normal lactations. Becker and McGillard assume that the normal lactation curve measures the combined influence of internal (hormonal) and external stimuli to milk secretion, whereas the "non-fecund" lactation measures the effect of the external stimuli only. Turner (4) mentions a similar case of lactation without pregnancy. He points out, however, that the separate effect of the external stimuli upon milk secretion can be measured only in ovariectomized and hypophysectomized animals. That hormonal stimuli were partly responsible for the initiation and increase of milk secretion in the heifer 10A need not be doubted.

It seems to be definitely established that milk secretion is initiated by a hormone produced by the anterior lobe of the hypophysis. According to Riddle, Bates and Dykshorn (2), this hormone is quite distinct from the other known pituitary hormones, and it is called by them "Prolactin." The mammary gland must, however, apparently first be "sensitized" by the ovarian hormones, estrin and progestin, before the pituitary hormone is effective. Beginning at puberty the animal is at certain intervals under the influence of the ovarian hormones, and during pregnancy this influence is accentuated and prolonged. The result is a certain development of the ducts and alveoli in the mammary gland (Turner, 5, 6). The secretory phase is induced by the pituitary hormone "Prolactin." The heifer 10A had, during her exaggerated sexual activity, for a long time been under the influence of the ovarian hormones, and it seems probable that her mammary glands were influenced by "Prolactin" also. The liberation of the "Prolactin" might have taken place partly as a response of the hypothesis to

the effect of the ovarian hormones, and partly as a result of the mechanical and psychical stimulation caused by milking and suckling.

The growth phase of the mammary gland of the heifer 10A did not reach the same level as it would have done during a normal pregnancy. Without the psychical and chemical stimulation of suckling and milking the secretion of milk would probably not have been initiated.

This case, and other similar cases reported in the literature, show that pregnancy is not indispensable to the development and functional activity of the mammary gland. A mammalian female may under certain conditions produce a considerable flow of normal milk without pregnancy. The time when the activity of the mammary gland may be artificially regulated by the administration of hormone preparations is perhaps not very far away.

SUMMARY

A case is reported of a barren heifer which, in response to sucking and milking, started to produce milk and continued to do so for 630 days. During the first six months of lactation there was a steady increase in the daily yield of milk, followed by a subsequent decline. The maximum daily yield was 18.7 pounds, and the total lactation yield was 5011.9 pounds. According to chemical analyses made the milk was normal in every respect. The probable causes of the initiation and increase in milk secretion are briefly discussed.

REFERENCES

(1) BECHER, R. B., and MCGILLARD, P. C. Measuring the influence of hormone and mechanical stimuli by means of a non-fecund lactation. JOUR. DAIRY SCI. 13: 372–379. 1930.

(2) RIDDLE, O., BATES, R. W., and DYKSHORN, S. W. A new hormone of the anterior pituitary. Proc. Soc. Exp. Biol. and Med. 29: 1211–1212. 1932.

(3) SPANN, J. Milchabsonderung bei jungfräulichen Tieren. Züchtungskunde 4: 77–94. 1929.

(4) TURNER, C. W. The development of the mammary gland as indicated by the initiation and increase in the yield of secretion. Missouri Agr. Exp. Station, Research Bul. 156, 48 pp. 1931.

(5) TURNER, C. W., and GARDNER, W. U. The relation of the anterior pituitary hormones to the development and secretion of the mammary gland. Missouri Agr. Exp. Station, Research Bul. 158, 57 pp. 1931.

(6) TURNER, C. W., and FRANK, A. H. The effect of the ovarian hormones theelin and corporin upon the growth of the mammary gland of the rabbit. Missouri Agr. Exp. Station, Research Bul. 174, 28 pp. 1932.

FACTORS CONTRIBUTING TO AN OFF-FLAVOR IN ICE CREAM*

C. D. DAHLE AND E. C. FOLKERS

Dairy Department, Pennsylvania State College

For a number of years ice cream manufacturers have experienced a distinct off-flavor in ice cream flavored with certain fruits, particularly strawberries. This particular off-flavor is characterized by a stale, tallowly, metallic taste which is decidedly objectionable. Since strawberry ice cream ranks as the third greatest seller of all flavors, the problem is one of considerable importance.

In order to determine the prevalence of this defect, a questionnaire was mailed in 1930 to 200 ice cream manufacturers in the United States. Seventy-seven replies were received from a total of 31 states. Sixty-five per cent of those reporting stated that they had experienced the off-flavor in strawberry ice cream, particularly in the winter months. Replies also indicated that the off-flavor did not appear to be so prevalent when fresh berries were used instead of cold pack or canned berries. This might lead one to believe that the problem may be seasonal or that it can be corrected by the use of fresh berries.

The replies to the questionnaire also indicated that the off-flavor may occur in from two days to a month's time, with the majority reporting that one to two weeks were usually required for the appearance of the flavor.

At the time this study was started there was little information in the literature dealing with this particular subject. Considerable work had been done to determine best methods for putting up and storing berries. Mudge and Tucker (1) studied the effect of air on discoloration of the berries and on the flavor of the ice cream. They found that when the berries had been aerated by drawing air through a 2–1 pack for considerable time, the ice cream flavored with these berries was "stale" and "unclean" as compared to the flavor of the control sample which was described as "good." Fresh berries which had been aerated gave the same results. Berries heated to 170° F. were superior to those unheated, while berries heated in a copper kettle produced ice cream inferior to ice cream flavored with berries heated in glass.

Mack and Fellers (2), working with various types of berries, reported no particular off-flavor. The mix these authors used contained cream and dry skimmilk. The fact that they used dry skimmilk as the source of additional serum solids may have accounted for their failure to find any off-flavors. This will be explained later.

Received for publication December 23, 1932.

* Publication authorized by the Director of the Pennsylvania Agricultural Experiment Station as Technical Paper No. 572.

There are several known causes for "tallowy" or "cardboard" flavored milk and milk products. Since there is a similarity in the type of off-flavor in these products to that produced in strawberry ice cream, it was thought that there might be a connection between them. Frazier (3) found a "cardboard" flavor to be present in whole milk that had been exposed to diffused daylight and the defect appeared more readily in pasteurized milk than raw milk. Light rather than bacteria or enzymes was considered to be a source of the difficulty. Tracy and Ruehe (4) reported two types of flavor defects in milk which had been exposed to sunlight, one being a tallowy flavor and the other a burnt flavor. Skimmilk was found to develop a burnt flavor upon exposure to the sun's ray's indicating that the serum of the milk may be affected. Davies (5) suggested that oxygen, in the presence of copper dissolved in the milk, may be the cause of the "cardboard" flavor.

Copper has long been known to cause "tallowy" flavors in certain dairy products. Copper is a normal constituent of cow's milk but excessive amounts of copper in milk may be traced to contamination from utensils and equipment used in the handling of milk. Supplee and Bellis (6) examined freshly drawn milk and found the normal copper content to be 0.521 mg. per litre, while King and Etgel (7) found 0.45 parts per million to be present in raw milk.

Guthrie, Roadhouse and Richardson (8) state that "The oxidized and related flavors of milk, such as 'astringent,' 'papery,' 'oily' and metallic, are believed to be caused largely by copper, the reaction being greatly accelerated if the milk is subsequently exposed to sunlight."

Working with sweetened condensed milk, Rice (9) found that tallowiness was produced in this product through the action of oxygen of the air in the container on the butterfat of the milk, the reaction being catalyzed ordinarily by small amounts of copper.

Milk, cream and condensed milk come in contact with copper when the tinning has worn off the equipment used. Unless this exposed copper is kept shiny and free from oxide, the possibility of some of the copper being dissolved by the milk product is great. Rice and Miscall (10) found that about three times as much copper was dissolved at 145° F. as was dissolved at room temperature or at the boiling-point. Others (11) have also shown that copper will be dissolved to a greater extent at a temperature around 140–145° F. Rice (9) states that copper condensing pans and hot wells that have not been used regularly yield an excessive amount of copper to the first few batches of milk manufactured. Exposing milk in a copper vacuum pan (6) for 1½ to 2 hours at a temperature of 110–120° F. increased the copper content from 0.38 to 2.98 mg. per litre, calculated on the basis of fluid milk. King and Etgel (7) found an average copper con-

tent of 3.7 parts per million in skimmed milk that was concentrated to 36 per cent total solids in a copper vaccuum pan.

Since copper has proved to be an important factor in deterioration of dairy products and because of the opportunity milk has of becoming contaminated with copper, the possibility of copper as a contributing factor to the cause of the particular off-flavor in question was thought highly probable.

SCOPE OF INVESTIGATION

Ice cream manufacturers in many instances have curtailed the manufacture of strawberry ice cream during the winter months because of the difficulty experienced with the keeping quality of the product. The thought held by some was to the effect that the use of cold pack berries was responsible for the defect. A close check-up on the age of the ice cream no doubt would have shown that the ice cream turnover was not as great during those months as in the summer months when the trouble seemed to abate. Returned goods having the off-flavor offered a problem in utilization that was difficult to solve.

The purpose of this investigation was to determine the underlying causes for the prevailing off-flavor and to offer a solution for the defect if possible. A study of various types of berries used, treatment of the berries, effect of quality and source of the dairy products used and the effect of copper contamination were studied. Several other factors such as the amount of flavoring used, acidity, neutralization, etc., were also given attention. Considerable work was done to determine if the defect was due to a decomposition of the butterfat as the off-flavor resembled certain defects resulting from deterioration of the fat.

METHODS

The ice cream mixes used tested for the most part 12 per cent fat, 10.5 per cent serum solids, 15 per cent sugar, 0.35 per cent gelatin and 37.85 per cent total solids. These mixes were made from various dairy products as the occasion demanded. Unless otherwise stated, they were all pasteurized at 150° F. for 30 minutes. Only a few of the mixes prepared were homogenized as small batches of approximately one gallon to 6 quarts capacity were used.

Most of the mixes were frozen in a small six quart ice and salt freezer. After freezing the samples were placed in the hardening room until hardened. A duplicate sample was then placed in an electric cabinet and scored for flavor at regular intervals.

LABORATORY METHODS

Such routine tests as acid test, hydrogen-ion concentrations, etc., were performed by the usual accepted methods.

Copper determinations were made by the method described by Gebhart and Sommer (12). To obtain comparative figures, the amount of copper present in the condensed skimmilk and the dry skimmilk was calculated on the skimmilk basis.

To determine the degree of oxidation of the butterfat, the length of induction period of oxygen absorption was determined by the static oxidation method as used by Triebold (13). This method consisted in weighing 20 grams of the pure dry butterfat being studied into a 500 cc. flask, connected to a gas burette. The flask and sample were then placed in an accurately controlled thermostat at 90° C. As soon as the flask and sample had attained the temperature of the thermostat, the air in the entire system was replaced by oxygen, and the time noted until there was a definite absorption of oxygen by the fat, as evidenced by a decrease in pressure within the system. The amounts of oxygen absorbed for definite intervals of time thereafter were also determined. The length of time the butterfat was in contact with oxygen before any consistent and measurable oxygen absorption took place was taken as the induction period, while the amounts of oxygen absorbed for definite intervals of time gave an indication of the rate of oxidation of the butterfat.

EXPERIMENTAL

Effect of Type of Berries on the Off-Flavor

Many replies to the questionnaire sent to manufacturers indicated that the off-flavor was not present when fresh berries were used. Therefore a mix was made from fresh cream, fresh condensed skimmilk and fresh skimmilk as sources of dairy products. Three types of berries were used, namely: frozen (3–1 pack), fresh berries, and canned berries. The amount of berries used approximated 10 per cent of the finished ice cream. The results may be noted in table 1.

TABLE 1

The effect of type of strawberries on the off-flavor in ice cream

TYPE OF BERRIES USED	CONDITION OF FLAVOR	
	After 12 days	After 15 days
Frozen Berries (old stock)	Flavor good	Flavor slightly "off"
Canned Berries	Flavor good	Flavor "off"
Fresh Berries	Flavor good	Flavor "off"

The results appearing in table 1 show that the type of the berries used was not a factor in producing the off-flavor. These results were duplicated on several occasions.

Effect of Amount of Berries Used

One manufacturer replying to the questionnaire stated that by increasing the amount of berries added he was able to eliminate the difficulty. An

experiment was made to determine the effect of a larger amount of berries. Four mixes were made in the usual way but each one containing condensed skimmilk from different sources. These results are listed in table 2.

TABLE 2

The effect of increasing the amount of flavoring on the appearance of the off-flavor

TREATMENT	CONDITION OF FLAVOR	
	After 15 days	After 41 days
10% Berries and Condensed Milk No. 1	Flavor good	Flavor good
20% " " " " " 1	" "	" "
10% " " " " " 2	" "off"	" "off"
20% " " " " " 2	Flavor slightly "off"	Flavor slightly "off"
10% " " " " " 3	Flavor good	" " "
20% " " " " " 3	" "	" " "
10% " " " " " 4	" "	Flavor "off"
20% " " " " " 4	" "	Flavor slightly "off"

It may be seen that an increase in the amount of berries used delayed the appearance of the off-flavor. An increase in amount of flavoring used no doubt tended to mask the off-flavor. Where condensed milk No. 1 was used there was an absence of the off-flavor. This indicated that the condensed milk used has an influence on the appearance of the flavor. Further proof of this will be shown later.

The Effect of Other Fruits on the Occurrence of the Off-Flavor

Just why strawberries should be the only fruit that concerns the ice cream manufacturer and not other fruits has been a matter of conjecture. The reason that more attention is paid to strawberry ice cream is possibly due to the fact that considerably more strawberries are used than other fruits.

Ice cream was flavored with an equal amount of canned red and black raspberries, canned pineapples, and a commercial fruit mixture known as fruit salad, with results that follow.

TABLE 3

The effect of aged dairy products and butterfat on the off-flavor

FRUITS USED	CONDITION OF FLAVOR			
	After 4 days	After 7 days	After 25 days	After 38 days
Strawberry	Flavor "off"	Flavor "off"	Flavor "off"	Flavor "off"
Red Raspberry	" good	" good	" good	" slightly "off"
Black Raspberry	" "	" "	" "	" " "
Pineapple	" slightly "off"	" "off"	" "off"	Flavor "off"
Fruit Salad	Flavor good	" good	" good	" good

Table 3 shows plainly that pineapple ice cream is capable of developing the off-flavor as well as strawberry, while the red and black raspberry ice cream remain in good condition for a longer period. The fruit salad ice cream did not develop the flavor in 38 days. This may be due to the fact that the fruit salad used was quite highly flavored, which may have masked the off-flavor.

All of these samples as well as those recorded in tables 1 and 2 were held in an electric cabinet during the period of the experiment except for the time necessary to harden them in the hardening room. A preliminary trial showed that the off-flavor will occur in the hardening room at a temperature of $-5°$ F. as readily as in the electric cabinet.

As stated earlier the ice cream mixes from which the ice cream was made were not homogenized. When a homogenized mix was used in a few preliminary trials it was found that the off-flavor was delayed considerably. This difference cannot be explained by the authors and is somewhat different from results obtained by Dorner and Widmer (14) who found that homogenized raw milk and cream became rancid quicker than the unhomogenized product because of the increased fat surface exposed to the hydrolyzing agent, lipase.

Effect of Heat Treatment on the Off-Flavor

Since bacteria and enzymes are known to affect flavors in dairy products and that yeasts and molds affect strawberries, it appeared possible that these might have a bearing on the subject in question.

To determine the effect of yeast, molds, enzymes, and bacteria, a regular ice cream mix was made and pasteurized at 150° F. for 30 minutes. A portion of this mix was heated to 180° F. for one hour as also was a portion of the strawberries. The combinations used and the results obtained are to be found in table 4.

TABLE 4

The effect of heating the ingredients of strawberry ice cream in the occurrence of the off-flavor

HEAT TREATMENT OF MIX AND BERRIES	CONDITION OF FLAVOR	
	After 4 days	After 7 days
Berries heated 180° F. for one hour Mix heated 150° F. for 30 minutes	Flavor slightly "off"	Flavor "off"
Berries not heated Mix heated 150° F. for 30 minutes	Flavor "off"	Flavor "off"
Berries heated 180° F. for one hour Mix heated 180° F. for one hour	Flavor good	Flavor "off"
Berries not heated Mix heated 180° F. for one hour	Flavor good	Flavor "off"

As the majority of the organisms and enzymes are killed at 180° F. for one hour it may be said from the results listed above that it is not probable that the off-flavor is due to a decomposition of the mix ingredients by these factors, unless possibly the end products of the organisms or enzymes had influenced certain conditions favorable to the production of the off-flavor before the heat had been applied. The flavor of the ice cream was greatly affected by the heat applied to the mix.

The Effect of Fruit Acid on the Development of the Off-Flavor

It is assumed that some factor in the berries is responsible for the off-flavor. The acidity of the strawberries used in these experiments ranged from 0.55 to 1.0 per cent calculated as malic acid. In this experiment the acidity was neutralized with sodium bicarbonate to pH 7. A previous experiment in which the acidity of the berries was reduced to that of the mix showed that the off-flavor still persisted. Table 5 shows that the acid of the berries used is a dominant factor, but the possibility of neutralizing the acid is not to be recommended because of the necessity of the acid to produce certain characteristics found in strawberry flavor.

TABLE 5

The effect of fruit acid on the off-flavor

TREATMENT OF BERRIES	CONDITION OF FLAVOR	
	After 4 days	After 25 days
Untreated Berries	Flavor "off"	Flavor "off"
"Neutralized" Berries	No off-flavor	No off-flavor

The Quality of the Milk Products Used and the Effect on the Off-Flavor

Many undesirable flavors in ice cream and other dairy products may be directly traced to the quality of the ingredients used. Replies to the questionnaire sent out to manufacturers indicated that the off-flavor commonly found in strawberry ice cream may be due to the use of frozen cream, storage cream and butter. To study the effect of old materials several mixes were made from cream and condensed skimmilk of different ages. One day old cream and condensed milk were compared with cream and condensed milk over one week of age. The ice cream was kept in the hardening room for the entire period of the study.

Not a great deal of difference in flavor was noted in this experiment. In fact it cannot be said that the aged materials used were necessarily responsible for any increase in the off-flavor. To obtain further information on this subject another set of experiments was made in which the age of the cream and condensed milk was studied. In this experiment butterfat from

TABLE 6

The effect of age of dairy products on the off-flavor

INGREDIENTS USED IN THE MILK	CONDITION OF FLAVOR	
	After 6 days	After 33 days
Fresh cream and fresh condensed milk	Flavor slightly "off"	Flavor slightly "off"
" " " aged " "	" " "	" " "
Aged cream and fresh " "	" " "	Flavor "off"
" " " aged " "	Flavor good	Flavor slightly "off"

cream was omitted from two mixes to note if the presence of butterfat was necessary to cause the off-flavor. The results of this trial may be noted in table 7.

TABLE 7

The effect of aged dairy products and butterfat on the off-flavor

INGREDIENTS USED IN THE MIX	CONDITION OF FLAVOR		
	After 12 days	After 17 days	After 25 days
Fresh cream & fresh cond. milk	Slightly "off"	Slightly "off"	Slightly "off"
Old " " " " "	Good	" "	"Off" (sour)
No " " " " "	"	" "	" "
" " " old " "	"	" "	"

This study again brings out the point as shown in table 6, that the age of the dairy products, particularly cream, caused no great difference in the degree of off-flavor, and that the presence of butterfat was not necessary for the production of the off-flavor.

The Relationship of "Cardboard Cream" to the Off-Flavor in Strawberry Ice Cream

To study further the relationship of dairy products to the off-flavor in strawberry ice cream, cream and skimmilk obtained by separating milk having a "cardboard" flavor were used. In this manner cream which had been subjected to treatment known to cause oxidation was used along with cream which had not been exposed to this treatment. The induction period of the butterfat in the fresh cream and "cardboard cream" was determined so that there would be some standard to use as a comparison.

To secure "cardboard cream," fresh pasteurized milk which had been cooled to 45° F. was placed in direct sunlight in Erlenmyer flasks for a period of two hours. The samples were then placed in a room at 40° F. for a period of 18 hours. A control sample was placed directly into the cooler without being exposed to sunlight. These two samples were then separated, the cream from both batches and skimmilk from the exposed sam-

ple being used at once in compounding the mixes. The cream which was separated from the exposed milk had a typical "cardboard" flavor while the skimmilk had a burnt flavor. Freshly made condensed skimmilk and dry skimmilk (spray process) were used to furnish the extra serum solids. Frozen berries of good quality were used. The skimmilk obtained from the "cardboard" milk was used in all mixes of this series. Table 8 indicates the method of compounding the mixes and the time for the off-flavor to appear. The ice cream was kept in the hardening room during the scoring period.

The butterfat in the mixes, made from fresh cream and condensed skimmilk, fresh cream and dry skimmilk, as well as from "cardboard cream" with condensed skimmilk and dry skimmilk, was churned out of the ice cream after 18 days in storage and the induction period determined.

Upon examination of table 8 we find that the undesirable flavor appeared where condensed skimmilk was used to furnish the extra serum solids and that this undesirable flavor did not appear when dry skimmilk was used. This was true regardless of whether "cardboard cream" or fresh cream was used. The same was true in mixes where the fat was eliminated from the mixes. When the condensed skimmilk was omitted the off-flavor did not occur. It appears, therefore, that "cardboard cream" is not a factor in producing this off-flavor or that the initial "cardboard" flavor is covered up by the strawberry flavor.

TABLE 8

The effect of fresh cream and "cardboard cream" on the off-flavor in strawberry ice cream

INGREDIENTS USED IN THE MIX IN ADDITION TO "CARDBOARD" SKIMMILK	CONDITION OF FLAVOR		
	5 days	15 days	18 days
Fresh cream with fresh condensed skimmilk	Flavor "off"	Flavor "off"	Flavor "off"
Fresh cream with dry skimmilk	" good	" good	" good
"Cardboard cream" with fresh cond. skimmilk	" "off"	" "off"	" "off"
"Cardboard cream" with dry skimmilk	" good	" good	" good
Fresh cream omitting fresh cond. skimmilk	" "	" "	" "
"Cardboard cream" omitting fresh cond. skimmilk	" "	" "	" "
Fresh cond. skimmilk omitting cream	" "	" "off"	" "off"
Dry skimmilk omitting cream	" good	" good	" good

Figure 1 shows that exposure of milk to the sun's rays caused a shorter induction period of the butterfat, indicating that some oxidation of the fat had taken place due to the exposure of the milk and that the "cardboard" flavor might be due to oxidation of the fat. When this fat was used in a

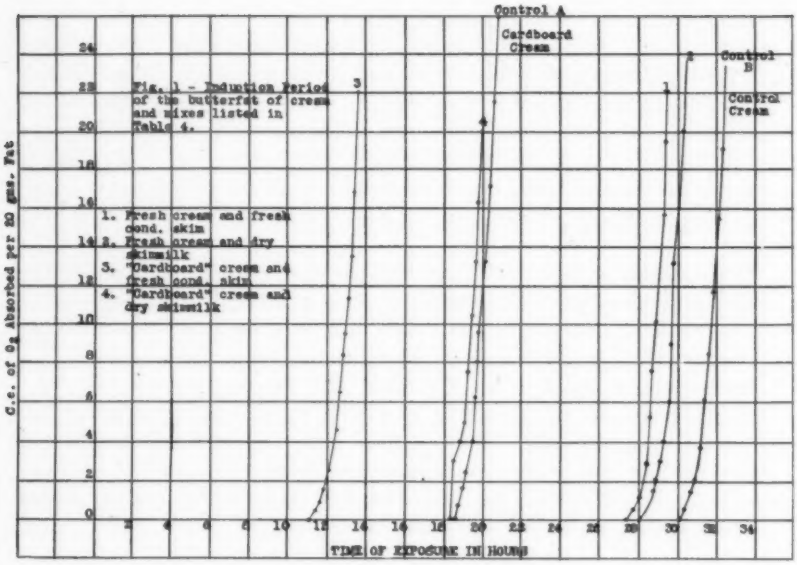

Control A
Cardboard Cream
Control B
Control Cream
1. Fresh cream and fresh cond. skim
2. Fresh cream and dry skimmilk
3. "Cardboard" cream and fresh cond. skim
4. "Cardboard" cream and dry skimmilk
c.c. of O_2 absorbed per 20 gms. Fat
TIME OF EXPOSURE IN HOURS

Fig. 1 - Induction Period of the butterfat of cream and mixes listed in Table 4.

mix, with dry skimmilk furnishing the solids, further oxidation did not take place. However, when condensed skimmilk was used the fat was further oxidized. When fat which had not been exposed was used, the induction period was only slightly affected, regardless of the source of serum solids.

Since the mixes which contained the condensed skimmilk were the only ones to develop the off-flavor, and since condensed skimmilk caused further oxidation of fat which had already been partly oxidized, we can conclude that the condensed skimmilk or some factor in the condensed skimmilk was one of the contributing factors causing the off-flavor to develop. This conclusion can also be drawn from the results of table 8 which shows that condensed skimmilk produced an identical off-flavor if fat was furnished by "cardboard" cream, fresh cream, or if the butter-fat was omitted entirely while dry skimmilk under the same conditions produced satisfactory flavors.

The foregoing experiment indicates that the "cardboard" flavor that was developed in the cream from which the ice cream was made was due to an oxidation of the butterfat and was accelerated by exposure to the sun's rays. This flavor was masked by the strawberries that were added to flavor the ice cream as the off-flavor was not present in the fresh ice cream. When dry skimmilk was used with this cream the usual off-flavor did not occur, but when condensed skimmilk was used it never failed to appear even with fresh cream. The presence of condensed skimmilk shortened the induction period in all cases but gave the off-flavor in cases where the induction period

was even longer than in cases where dry skimmilk was absent. These results tend to indicate that the off-flavor of strawberry ice cream is not due to an oxidation of the fat in cream, as has been generally supposed, and this idea is further substantiated by results reported in table 8, where in two cases cream was entirely omitted from the mix. In these mixes, however, there was a slight amount of fat present in the condensed skimmilk and skimmilk. It has been definitely established that some factor is present in the condensed milk to cause the off-flavor. From table 5, it would seem that the acid in the berries was also a factor.

The Relationship of the Source of Condensed Skimmilk and Dry Skimmilk to the Occurrence of the Off-flavor in Strawberry Ice Cream

Throughout all the work on strawberry ice cream it was noted that when dry skimmilk of the spray process was used to furnish the extra serum solids of the mix, the off-flavor did not appear. This experiment was performed, therefore, to determine if other types of dry skimmilk would produce ice cream with the same results. Two samples each of the three types of powder were used in preparing mixes as indicated in table 9.

TABLE 9

The effect of various skimmilk powders on the off-flavor in strawberry ice cream

INGREDIENTS USED IN ADDITION TO FRESH CREAM AND FRESH SKIMMILK	CONDITION OF FLAVOR		
	8 days	27 days	36 days
Fresh Cond. skimmilk	Flavor slightly "off"	Flavor "off"	Flavor "off"
Vacuum Roll Powder (1)	Flavor good	" good	" good
" " " (2)	" "	" "	" "
Atmospheric Roll Powder (1)	" "	" "	" "
" " " (2)	" "	" "	" "
Spray Powder (1)	" "	" "	" "
" " (2)	" "	" "	" "

These results indicate that the off-flavor did not occur when dry skimmilk was used regardless of the type used. This tends to show that the factor causing the off-flavor was present in the condensed skimmilk in sufficient amounts, but was not present in sufficient amounts in the dry skimmilk used. In all cases where dry skimmilk was used the strawberry flavor was practically as fresh after the holding period as it was in the fresh sample when fresh condensed skimmilk was used.

In the previous experiments the off-flavor was found to appear whenever condensed skimmilk was used. This condensed skimmilk, however, was all made in the college creamery. To obtain more information on the relation-

ship of the off-flavor in question to condensed skimmilk, condensed skimmilk was obtained from three different condensaries. Mixes were made from these condensed milks along with the mix containing the college condensed skimmilk. These condensed skimmilk samples were all of good quality. The results of this test are shown in table 10, as well as the results of another series of tests. In this latter series, the condensed skimmilk was made in two different vacuum pans, one pan being a copper pan which had supplied most of the condensed milk used previously, and the other being a tin-plated laboratory pan with copper coils. Skimmilk for this series was preheated in the same glass enameled hot well, leaving the pan as the only variable factor.

TABLE 10

The relationship of the source of condensed skimmilk to the off-flavor in strawberry ice cream

CONDENSED SKIMMILK USED	CONDITION OF FLAVOR			
	4 days	10 days	16 days	41 days
Series 1				
Cond. skimmilk No. 1	Flavor good	Flavor good	Flavor good	Flavor good
" " " 2	Flav. slightly "off"	" "off"	" "off"	" "off"
" " " 3	Flavor good	" good	" "	" "
" " " 4	" "	" "	" "	" "
Series 2				
Cond. skimmilk (A) (all copper plant pan)	Flav. slightly "off"	" "off"	" "	
Cond. skimmilk (B) (laboratory pan)	Flavor good	" good	" good	

The results of these two series indicate that not all condensed skimmilk will cause the development of the off-flavor in strawberry ice cream. In this experiment two samples of condensed skimmilk out of six did not produce the off-flavor while two samples produced the off-flavor within 4 days. Upon further examination of table 10 it is noted that the condensed skimmilk which was made in the all copper pan produced the off-flavor readily but skimmilk of the same source condensed in a tin-plated pan with copper coils (laboratory pan) but did not develop the off-flavor in strawberry ice cream in 16 days when it was used to furnish the extra serum solids in the mix. This points to copper as the factor in condensed skimmilk that is responsible for the development of the defect in question.

The Effect of Copper on the Appearance of the Off-flavor in Strawberry Ice Cream

Since it is known that the presence of copper causes off-flavors to appear in certain dairy products, and since in the previous experiment it was

demonstrated that condensed skimmilk made in a copper pan produced the off-flavor in strawberry ice cream, while condensed skimmilk made in a tin-plated pan did not produce the off-flavor, it appears that copper is the causative factor in producing the off-flavor in strawberry ice cream.

In order that this factor could be further demonstrated, copper determinations were made on the four samples of condensed skimmilk reported in the previous experiment. Table 11 shows the results of these determinations with the corresponding flavor results. The copper content reported is on the skimmilk basis of the condensed skimmilk so that all figures are comparable.

TABLE 11

The effect of copper in condensed skimmilk on the occurrence of the off-flavor in strawberry ice cream

CONDENSED USED TO FURNISH THE EXTRA SERUM SOLIDS NEEDED AND AMOUNT OF BERRIES USED	PARTS COPPER PER MILLION IN CONCENTRATED SKIMMILK BASED ON FLUID SKIMMILK	DAYS FOR FLAVOR TO APPEAR
Cond. No. 1 with 10 per cent berries	0.395 p.p.m.	Flavor good after 41 days
" No. 1 " 20 " " "	0.395 "	" " " 41 "
" No. 2 " 10 " " "	2.84 "	" "off" " 4 "
" No. 2 " 20 " " "	2.84 "	" " " 16 "
" No. 3 " 10 " " "	2.03 "	" " " 16 "
" No. 3 " 20 " " "	2.03 "	" " " 41 "
" No. 4 " 10 " " "	2.07 "	" " " 16 "
" No. 4 " 20 " " "	2.07 "	" " " 16 "
Powder Control with 10 per cent "	.592 "	" good " 41 "

In table 11 an explanation is offered as to the cause of the off-flavor appearing in strawberry ice cream when certain samples of condensed skimmilk is used, and why it does not appear when other samples are used. It will be noted that where condensed No. 2 was used with the regular amount of berries, the off-flavor appeared earliest and also that the copper content of this particular condensed milk was the highest. Condensed milk No. 3 and No. 4 were the next highest in copper content and were the next to develop the off-flavor while condensed milk No. 1 with only 0.395 p.p.m. on the milk basis produced ice cream which was still good in flavor after a period of 41 days. It is also shown that the powder control, although it added more copper to the ice cream mix than condensed milk No. 1, did not cause the appearance of the undesirable flavor. Table 11 further shows, as has been demonstrated before, that an increased amount of strawberries delays the early appearance of the off-flavor.

To demonstrate further the effect of copper in producing the off-flavor, a mix was made using a spray process dry skimmilk to furnish the extra serum solids. This mix was then divided into four parts and varying amounts of copper in the form of copper lactate were added before the

mixes were pasteurized. In a similar manner one set of mixes was made in which the fat was omitted and in another the source of extra serum solids, dry skimmilk, was omitted.

A copper determination on the control mix, after the berries were added, showed that it contained 0.8 mg. of copper per liter. Table 12 shows the amount of copper added and resulting flavors.

The off-flavor which developed by adding copper to a mix where dry skimmilk was used to furnish the extra serum solids, was identical to the off-flavor which developed when certain condensed skimmilk samples were used. Table 12 indicates that the greater the amount of copper present the shorter is the time necessary for the development of the off-flavor. In the case where the dry skimmilk is omitted we would expect a longer period necessary for the development of the off-flavor due to the fact that the milk powder contains some copper. This is the case as where 0.5 p.p.m. of copper were added to the regular mix it required 15 days for the development of the off-flavor, whereas it took 21 days where the powder was omitted. The period necessary for the off-flavor to develop in two of the mixes in which the fat was omitted was the same as where the extra solids were omitted.

TABLE 12

The effect of adding copper to mixes which had not developed the off-flavor

INGREDIENTS USED IN MIX	AMOUNT OF COPPER ADDED P.P.M.	TIME FOR FLAVOR TO DEVELOP
Cream, powder, skimmilk (containing 0.8 p.p.m. of copper	None	Flavor good after 27 days
Cream, powder, skimmilk (containing 0.8 p.p.m. of copper	0.5	" "off" " 15 "
Cream, powder, skimmilk (containing 0.8 p.p.m. of copper	1.0	" " " 9 "
Cream, powder, skimmilk (containing 0.8 p.p.m. of copper	2.0	" " " 3 "
Cream and skimmilk without added solids	None	" good " 27 "
" " " " " "	0.5	" "off" " 21 "
" " " " " "	1.0	" " " 3 "
" " " " " "	2.0	" " " 3 "
Powder and skimmilk without fat	None	" good " 27 "
" " " " "	0.5	" "off" " 21 "
" " " " "	1.0	" " " 15 "
" " " " "	2.0	" " " 9 "

From this experiment we can conclude that when copper is present in an ice cream mix to an extent of 0.8 p.p.m. the flavor defect due to the copper may not be experienced, and furthermore, if as much as 1.3 p.p.m. of copper are present, the off-flavor may develop.

The Effect of Methods of Handling Concentrated Dairy Products on the Appearance of the Off-flavor in Strawberry Ice Cream

The previous experiments have shown that the copper in the condensed skimmilk is an active agent in producing the off-flavor in strawberry ice cream. It has also been shown that not all samples of condensed skimmilk are effective in producing the off-flavor.

An experiment was performed to determine to what extent condensed skimmilk was contaminated with copper due to the vacuum pan. Copper determinations were made upon condensed skimmilk which had been made in a copper pan and on condensed milk from the same source of skimmilk made in a tin-plated pan with copper coils. Copper determinations were also made on two samples of dry skimmilk, which had been dried from condensed milk, one of which had been exposed to a copper pan while the other had not been exposed to copper. These four samples were used in compounding ice cream mixes as shown in table 13. Copper in the form of copper lactate was added to the two mixes which contained the milk powders.

TABLE 13

The effect of methods of handling concentrated dairy products on the appearance of the off-flavor in strawberry ice cream

CONCENTRATED PRODUCT USED IN THE MIX AND ITS TREATMENT	P.P.M. OF COPPER ON MILK BASIS OF CONCENTRATED PRODUCT	TIME TO PRODUCE THE OFF-FLAVOR
Condensed skimmilk from copper pan	1.78	Flavor "off" in 7 days
" " " tin-plated pan	.691	" good after 27 days
Dry skimmilk from copper pan	.285	" " " 27 "
" " " " " plus 1 p.p.m. of copper in mix		" "off" in 7 "
Dry skimmilk not exposed to copper	.173	" good after 27 "
" " " " " " plus 1 p.p.m. of copper in mix		" "off" " 7 "

Table 13 shows that there is nearly three times as much copper present in condensed skimmilk which was condensed in a copper vacuum pan as there was in the condensed skimmilk which was condensed in a tin-plated pan. It is also shown that the off-flavor did not appear in 27 days when condensed skimmilk from the tin-plated pan was used. The dry skimmilk which resulted from milk that had been condensed in a copper vacuum pan also showed more copper than the dry skimmilk which was not exposed to copper. In this case the powder did not provide enough copper to the mix to produce the off-flavor, however, when as low as 1 p.p.m. of copper was added to the mixes containing these powders the off-flavor appeared as soon

as in the mixes employing condensed skimmilk which had been made in a copper pan.

This experiment shows very conclusively that copper is the factor causing the off-flavor to appear in strawberry ice cream, also that the method of handling dairy products is very important from the standpoint of copper contamination.

The Effect of Copper, Neutralized Berries, and Increased Amount of Berries on the Off-flavor in Strawberry Ice Cream

The previous experiments have shown that the off-flavor in strawberry ice cream is caused by an excess amount of copper in the mix. It has also been shown that the acid which is contained in the berries is necessary for

TABLE 14

The effect of copper, neutralized berries, and increased amount of berries on the off-flavor in strawberry ice cream

MIX NO.	CONCENTRATED PRODUCT USED IN THE MIX AND TREATMENT OF BERRIES	CONDITION OF FLAVOR					
		7 days		13 days		27 days	
1	Cond. A (copper pan, 1.78 p.p.m. of copper) plus 10 per cent berries	Flavor	"off"	Flavor	"off"	Flavor	"off"
2	Cond. A plus 10 per cent berries and citric and malic acid	"	slightly "off"	"	"	"	"
3	Cond. A plus 10 per cent berries, berries neutralized to pH 7	"	good	"	good	"	good
4	Cond. A plus 20 per cent berries	"	"	"	slightly "off"	"	"off"
5	Cond. B (tin-plated pan, .691 p.p.m. of copper) plus 10 per cent berries	"	"	"	good	"	good
6	Cond. B plus 10 per cent berries and citric and malic acid	"	"	"	"	"	"
7	Cond. B plus 10 per cent berries neutralized to pH 7	"	"	"	"	"	"
8	Cond. B plus 20 per cent berries	"	"	"	"	"	"
9	Powder A (made in copper pan, .285 p.p.m. of copper)	"	"	"	"	"	"
10	Powder A plus 1 p.p.m. of copper to mix and 10 per cent berries	"	"off"	"	"off"	"	"off"
11	Powder A plus 1 p.p.m. of copper to mix and neutralized berries	"	good	"	good	"	good

the copper to produce this defect, also that an increased amount of berries tends to delay the appearance of this off-flavor.

To confirm the above results, mixes were made using different samples of condensed skimmilk and dry skimmilk. The same mixes that were recorded in table 13 were used. To study the part played by the strawberries, a portion of the berries was neutralized to pH 7; to another portion acid was added to equal the amount that would be supplied by a 100 per cent increase in the amount of berries. This added acid was 90 per cent citric and 10 per cent malic. Table 14 shows the combinations used and the flavor results.

Table 14 indicates that both the acid of the berries and an abnormal amount of copper is necessary for the development of the off-flavor in strawberry ice cream. In mix No. 9 there was a small amount of copper added by the dry skimmilk but the off-flavor did not appear. However, when copper was added to this mix as in table No. 13 the off-flavor appeared readily. Furthermore, when this regular mix plus an added amount of copper was used with berries which had been neutralized to pH 7 as in mix No. 11 the off-flavor did not appear.

It may also be noted in this table that a 100 per cent increase in the amount of berries used lengthened the period for the off-flavor to develop from 7 to 13 days. However, if enough acid is added to the regular mix to equal that amount supplied by the increased amount of berries used, the off-flavor still appears. This indicates that the off-flavor is prevented from an early appearance due to a masking of the off-flavor by the higher fruit flavor and that the extra acid does not play a part in the prevention of this flavor defect.

This table summarizes, therefore, all factors which were found to be responsible for the development of the off-flavor in strawberry ice cream and those which prevented the early appearance of the off-flavor. These factors causing the off-flavor are, an abnormal amount of copper present in the ice cream, and the acid of the berries; while a higher flavored ice cream, obtained by increasing the amount of berries, tends to prevent the early appearance of the off-flavor.

SUMMARY

1. The off-flavor common to strawberry ice cream is not necessarily due to the type of strawberries used. The flavor was produced with fresh, cold pack, and canned strawberries.

2. Increasing the amount of strawberries from 10 per cent to 20 per cent of the ice cream mix delayed the occurrence of the off-flavor.

3. The off-flavor may occur in pineapple ice cream as readily as in strawberry ice cream.

4. Heating the strawberries and the ice cream mix to 180° F. for one hour did not prevent the off-flavor from appearing.

5. Neutralization of the acid of the berries to pH 7 delayed the off-flavor but the natural strawberry flavor was injured by this procedure.

6. The quality of the milk products used had little effect on the appearance of the off-flavor. "Cardboard" flavored cream and skimmilk failed to cause the off-flavor when dry skimmilk was used instead of condensed skimmilk. The absence of cream from the mix did not prevent the appearance of the off-flavor when certain condensed milks were used.

7. Condensed milks, containing a certain amount of copper, caused the off-flavor to occur. If the total amount of copper in the mix equalled 1.3 p.p.m., the flavor always developed.

8. The off-flavor never occurred when three types of dry skimmilk were used instead of condensed milk, because these powders did not add sufficient copper to the mix to cause the off-flavor.

CONCLUSIONS

1. The cause of the off-flavor in strawberry ice cream was due to the presence of copper and the acid of the fruit.

2. The copper content necessary to produce the off-flavor in these experiments was found to be in the neighborhood of 1.3 p.p.m. in the finished ice cream.

3. The most important source of the copper contamination was found to be the copper vacuum pan.

4. Copper vacuum pans that are in daily use or those kept well polished on the inside need not necessarily be a serious source of contamination, but pans not kept well polished proved to be an important source of the trouble.

REFERENCES

(1) Mudge, C. S., and Tucker, L. O. The cold pack method of preserving strawberries. Ice Cream Field **19**: 340. 1931.

(2) Mack, M. J., and Fellers, C. R. Frozen fruit for ice cream. Ice Cream Trade Jour. **25**: 859. 1929.

(3) Frazier, Wm. C. A defect in milk due to light. Jour. Dairy Sci. **21**: 375. 1928.

(4) Tracy, P. H., and Ruehe, H. A. The relation of certain plant processes to flavor development in market milk. Jour. Dairy Sci. **14**: 250. 1931.

(5) Davies, W. L. The action of strong sunlight on milk. Reviewed in Int. Assoc. of Milk Dealer's Abstract, Vol. 1, 76. 1931.

(6) Supplee, G. C., and Bellis, B. The copper content of cow's milk. Jour. Dairy Sci. **5**: 455. 1922.

(7) King, C. C., and Etgel, G. Copper as an industrial contaminant in foodstuffs. Ind. and Eng. Chem. **19**: 1004. 1927.

(8) Guthrie, E. S., Roadhouse, C. L., and Richardson, G. A. Hilgardia **5**: 14 (Calif. Agr. Exp. Sta.). 1930.

(9) RICE, FRANK E. Sweetened condensed milk. VI. Tallowiness. JOUR. DAIRY SCI. 9: 459. 1926.

(10) RICE, FRANK E., and MISCALL, J. Copper in dairy products and its solution in milk under various conditions. JOUR. DAIRY SCI. 6: 261. 1923.

(11) MISCALL, J., CAVANAUGH, G. W., and CARODEMOS, P. P. Copper in dairy products and its solution in milk under various conditions—II. JOUR. DAIRY SCI. 12: 379. 1929.

(12) GEBHART, H. T., and SOMMER, H. H. Determination of copper in dairy products. Ind. and Eng. Chem., Analytical Edition, III, 24. January, 1931.

(13) TRIEBOLD, H. O. Rancidity. Cereal chemistry. 9: 55. 1932.

(14) DORNER, W., and WIDMER, A. Rancidity in milk due to homogenization. Abstract in Food Industries 4: 284. 1932.

THE EFFECT OF FEEDING A COD-LIVER OIL CONCENTRATE TO COWS ON THE VITAMIN D CONTENT OF MILK

W. E. KRAUSS, R. M. BETHKE, AND WILLARD WILDER

Departments of Dairy Industry and Animal Industry, Ohio Agricultural Experiment Station, Wooster

In an earlier paper (1) it was shown that irradiated ergosterol, when fed to cows, was an effective agent in bringing about a considerable increase in the vitamin D content of milk. At the same time it was shown that this procedure was too inefficient and too costly to warrant its adoption. The next vitamin D-containing supplement used was a cod-liver oil concentrate, known commercially as Vitex.[1] This product is prepared according to the Zucker process and contains practically no vitamin A.

EXPERIMENTAL

Six Holstein cows were fed a basal ration composed of second cutting, green leafy alfalfa, and the following grain mixture: 360 dried beet pulp, 200 yellow corn, 150 oats, 50 wheat bran, 50 linseed oilmeal, 4.5 salt. After the experiment had been in progress for some time the beet pulp was soaked and fed separately. Eighteen pounds of grain (including the beet pulp) and 12 pounds of hay were the allowances calculated to meet the daily requirements of the cows. This system of feeding, rather than one based on production, was followed in order to keep the food intakes of the cows equal and thus avoid any error through a greater or less intake of vitamin D in the basal ration. Towards the end of the experiment, as the cows decreased in milk flow, the hay allowance was reduced to 10 pounds per cow daily. On several occasions, owing to illness, the grain allowance of individual cows had to be reduced. These periods of lowered grain intake were usually of short duration and did not influence the results, especially when it is considered that grains contain practically no vitamin D.

The cows were fed and milked twice daily. The amount of milk produced at each milking was recorded and a butterfat test was made once a week on a one-day aliquot composite sample of milk from each cow. The cows were allowed to exercise for several hours each day in a vegetation-free enclosure.

At the end of 17½ days of feeding on the basal ration the cows were divided into two groups of three cows each. This division was made in such

Received for publication January 12, 1933.

Published with the permission of the Director of the Ohio Agricultural Experiment Station.

[1] Vitex, manufactured by the National Oil Products Co., Harrison, N. J., to which concern the authors are indebted for a fellowship which made this work possible.

a way that the total milk and fat production of the groups were approximately equal. During the next four days the milk from each group was collected separately. This was separated each day and aliquot composite samples of cream were obtained. The cream was then churned and the resulting butter was rendered into pure fat. During the last four days of each period of the experiment fat samples were obtained in a similar manner.

The feeding program followed is given in table 1. The amounts of

TABLE 1

Experimental feeding plan

PERIOD	DATE	RATIONS FED	
		GROUP I	GROUP II
I	*1932* Jan. 4–Jan. 25 (21½ days)	Basal	Basal
II	Jan. 25–Feb. 18 (24 days)	Basal Plus 6,000 rat units of Vitex	Basal Plus 15,000 rat units of Vitex
III	Feb. 18–March 21 (32 days)	Basal	Basal
IV	Mar. 21–Apr. 14 (24 days)	Basal Plus 40,000 rat units of Vitex	Basal Plus 60,000 rat units of Vitex
V	Apr. 14–May 13 (29 days)	Basal	Basal

Vitex fed during Periods II and IV were based upon assays made in our own laboratory. Solutions of Vitex and corn oil (Mazola) were made up in such a way that 50 cc. would furnish the required number of rat units of vitamin D for one cow. This amount was measured out for each animal daily and mixed with the afternoon's grain allowance.

The technique employed in making the butterfat assays was as follows:

The offspring of stock females were weaned at 24 days of age, when they weighed from 50 to 60 grams. The young were then placed, by litters, in galvanized wire cages with raised bottoms, and allowed free access to Steenbock and Black's diet and distilled water. The animals were housed in a darkened room. At the end of 21 days those rats showing symptoms of marked rickets (enlarged wrists, depressed thorax, and rachitic gait) were removed to individual cages and distributed in such a way that a representative of each litter was in each group, as nearly as possible.

The animals were allowed free access to Steenbock and Black's diet, but the amount eaten each day was determined. Melted butterfat was fed in a separate dish daily for 8 days. The fat was measured out with a calibrated pipette or eye dropper, depending upon the amount fed. After 8 days of supplementary feeding, the rats were given the Steenbock and Black diet only for 2 days.

At the end of 10 days the animals were chloroformed and the radii and ulnae removed. These were placed in 5 per cent formalin for not less than 4 hours, after which the standard McCollum line-test procedure was followed. That amount of butterfat giving a narrow continuous line was designated as the critical level.

RESULTS

The results of the butterfat assays are summarized in table 2. Although several different levels of each butterfat sample were fed, the critical level only is shown in this table. It is evident that when Vitex was fed the vitamin-D content of the butterfat was greater than that obtaining when

TABLE 2

The critical amount of butterfat required, daily, to produce definite evidence of healing in rats

FAT SAMPLES		RAT UNITS OF VITAMIN D FED TO COWS DAILY	NUMBER OF RATS	CRITICAL DAILY LEVEL OF BUTTERFAT	RAT UNITS OF VITAMIN D PER GM. BUTTERFAT
Period	*Group*			*mg.*	
I	I	None	14	1,500	0.083–
	II	None	13	1,500	0.083–
II	I	6,000	14	800	0.156
	II	15,000	13	400	0.313
III	I	None	7	1,500	0.083–
	II	None	7	1,500	0.083–
IV	I	40,000	14	225	0.556
	II	60,000	14	150	0.833
V	I	None	5	750	0.167
	II	None	5	750	0.167

the basal ration only was fed and that as the amount of Vitex fed increased the amount of vitamin D in the butterfat increased. The exact potency of the butterfat produced during Periods I and III could not be determined as the rats would not regularly consume more than 1500 mg. of fat daily.

Based upon the vitamin D potencies given in table 2, the number of rat units of vitamin D produced per quart of milk during each period was calculated (Table 3). When the basal ration only was fed the milk contained

less than 2.76 rat units of vitamin D per quart; when 60,000 rat units of D as Vitex were fed the milk contained 30.35 rat units per quart. Thus, at least an eleven-fold increase in the D-potency of the milk resulted.

TABLE 3

Fat production and Steenbock rat units of vitamin D produced per quart of milk

PERIOD	GROUP	PER CENT FAT	FAT PER QUART OF MILK	RAT UNITS PER GRAM OF FAT	RAT UNITS PER QUART OF MILK
			gm.		
I	I Control	3.35	33.43	0.083	2.77
	II Control	3.33	33.26	0.083	2.76
II	I 6,000 r.u. of Vitex	3.41	34.03	0.156	5.31
	II 15,000 r.u. of Vitex	3.52	35.13	0.313	11.00
III	I Control	3.60	35.93	0.083	2.98
	II Control	3.72	37.13	0.083	3.08
IV	I 40,000 r.u. of Vitex	3.57	35.63	0.556	19.81
	II 60,000 r.u. of Vitex	3.65	36.43	0.833	30.35
V	I Control	3.32	33.13	0.167	5.53
	II Control	3.61	36.03	0.167	6.02

In addition to the effect upon increasing the vitamin-D content of the milk, it was of interest to determine whether or not the feeding of Vitex influenced in any way the milk production, fat percentage, total fat, and physical condition of the cows. The cows were carefully observed daily and nothing unusual was detected in their behavior or physical condition when Vitex was fed.

From the daily milk records and weekly butterfat tests, the data in table 1 were calculated. It is apparent that total milk and fat production decreased as the experiment progressed, this being particularly noticeable during Periods IV and V. There were no indications that this was related in any way to the feeding of Vitex and can probably be attributed to the normal decrease in production which accompanies advancing lactation. The considerable drop in production which occurred in Group I during Period III was due to the substitution of a lower-producing cow (No. 4) for one which had suddenly died (No. 5), and the relatively large drop which occurred in the same group during Period IV was partly due to illness of cow No. 2. The death of cow No. 5 and the illness of cow No. 2 were not due to the feeding of Vitex. In the light of these considerations,

TABLE 4

Daily milk and fat production

PERIOD	RATION	COWS	MILK	FAT	PER CENT FAT
			lb.	*lb.*	
	Basal	2	32.4	1.13	3.49
		5	45.8	1.52	3.32
		380	37.1	1.21	3.24
I			115.3	3.86	
	Basal	1	48.5	1.77	2.91
		3	38.1	1.24	3.25
		382	33.3	1.27	3.83
			119.9	4.28	
	Basal Plus 6,000 r.u. of Vitex	2	30.8	1.12	3.62
		5	45.2	1.56	3.46
		380	38.3	1.22	3.19
II			114.3	3.90	
	Basal Plus 15,000 r.u. of Vitex	1	43.5	1.25	3.08
		3	34.1	1.11	3.45
		382	29.8	1.14	4.04
			107.4	3.50	
	Basal	2	35.8	1.01	3.92
		4	28.2	1.03	3.66
		380	37.3	1.20	3.21
III			101.3	3.24	
	Basal	1	39.8	1.38	3.47
		3	32.1	1.19	3.70
		382	31.6	1.27	4.00
			103.5	3.84	
	Basal Plus 40,000 r.u. of Vitex	2	30.0	1.10	3.67
		4	28.1	1.10	3.93
		380	35.8	1.12	3.12
IV			93.9	3.32	
	Basal Plus 60,000 r.u. of Vitex	1	37.4	1.25	3.35
		3	34.2	1.22	3.56
		382	33.0	1.33	4.05
			104.6	3.80	
	Basal	2	30.4	1.11	3.64
		4	22.7	0.76	3.32
		380	34.0	1.02	3.00
V			87.1	2.89	
	Basal	1	33.0	1.12	3.41
		3	33.8	1.20	3.55
		382	32.4	1.25	3.86
			99.2	3.57	

the data in table 4 show that the feeding of Vitex at any of the levels for the length of time involved did not influence milk or fat production.

DISCUSSION

Drummond *et al.* (2) found that the feeding of relatively high doses of cod-liver oil (8 oz.) to cows depressed the fat percentage of the milk. A similar observation was made by Steenbock and coworkers (3). That this phenomenon was not restricted to cod-liver oil was shown by Brown and Sutton (4) who noted a decided depression in the butterfat percentage of milk from cows fed up to 0.8 lb. of menhaden fish oil daily. On the other hand, one pound of corn oil daily exerted no significant influence on the per cent of fat in milk (5). As suggested by these authors, the fat-depressing action of fish oils may be due to their unsaturated fatty acids or some unknown factor, and is probably not associated with vitamin D or a high fat intake. The reason no drop in fat percentage was noted when Vitex was fed was either due to the fact that such a small amount of material was fed or that the specific fat-depressing factor in cod-liver oil was removed in the process of preparing the concentrate.

So far as total milk and fat production were concerned, the periods were hardly long enough to warrant any definite conclusion as to the effect that long-continued feeding of Vitex might have.

Although at least an eleven-fold increase in the amount of vitamin D per quart of milk resulted when 60,000 rat units of Vitex were fed per cow daily, this increased potency (30.35 rat units per quart) was much under that found by Hess, Lewis, MacLeod and Thomas (6) to be desirable (160 rat units per liter). It must be pointed out in this connection that the amount of vitamin D in the milk produced by our cows when on the basal ration was very small.

Another factor of prime importance in considering possible methods for increasing the vitamin D content of milk is the practicability of the operation. From the cost standpoint alone, the use of Vitex for this purpose is beyond consideration.

SUMMARY AND CONCLUSIONS

When a cod-liver oil concentrate (Vitex) was fed to cows the vitamin-D content of the milk increased as the amount of Vitex fed increased. When an ordinary dairy ration was fed the milk contained less than 2.76 Steenbock rat units of vitamin D per quart; when 60,000 rat units of vitamin D as Vitex were fed the milk contained 30.35 rat units per quart—at least an eleven-fold increase.

On this basis, the feeding of Vitex to cows for the purpose of increasing the vitamin D content of milk is too costly.

At least 60,000 rat units of vitamin D as Vitex may be fed to cows daily without affecting the physical condition or producing ability of the animals.

REFERENCES

(1) KRAUSS, W. E., BETHKE, R. M., and MONROE, C. F. The effect of feeding irradiated ergosterol to cows on the vitamin D content of milk. Jour. Nutrition 5: 467. 1932.

(2) DRUMMOND, J. C., CHANNON, H. J., COWARD, K. H., GOLDING, J., MACKINTOSH, J., and ZILVA, S. S. The influence of the administration of certain oils on the nutritive value of the butterfat of cows on winter rations. Jour. Agr. Sci. 14: 531. 1924.

(3) STEENBOCK, H., HART, E. B., HANNING, F., and HUMPHREY, G. C. Fat-soluble vitamins. XXX. The antirachitic value of cow's milk as modified by the feeding of irradiated yeast. Jour. Biol. Chem. 88: 197. 1930.

(4) BROWN, J. B., and SUTTON, T. S. The effect of feeding menhaden (fish) oil on the secretion of milk and the composition of butterfat in the dairy cow. JOUR. DAIRY SCI. 14: 125. 1931.

(5) SUTTON, T. S., BROWN, J. B., and JOHNSTON, E. W. The effect of corn oil on milk and butterfat production and on the composition of butterfat in the dairy cow. JOUR. DAIRY SCI. 15: 209. 1932.

(6) HESS, A. F., LEWIS, J. M., MACLEOD, F. L., and THOMAS, B. H. Antirachitic potency of the milk of cows fed irradiated yeast or ergosterol. Jour. Amer. Med. Assoc. 97: 370. 1931.

AMYL ALCOHOL AS A SOURCE OF ERROR IN THE GERBER TEST

B. L. HERRINGTON

Department of Dairy Industry, Cornell University, Ithaca, N. Y.

The Gerber test for butterfat is used in a number of places in the United States. Many of those using the test do not appreciate the possibility of serious errors in the test due to the use of the wrong kind of amyl alcohol. The makers of the equipment for this test mention the fact that the alcohol must have a boiling-point between 128° C. and 132° C. but the matter deserves greater emphasis.

The name "amyl alcohol" indicates a monohydric alcohol having five carbon atoms. There are eight of these amyl alcohols and they have quite different properties as is shown by table 1. Of these alcohols, iso-butyl-

TABLE 1

Physical properties of the isomeric amyl alcohols

	BOILING-POINT	SP. GR.
Normal primary butyl-carbinol	137.9° C.	0.817
Iso-butyl-carbinol	130.5	0.812
Secondary butyl-carbinol	128	0.816
Methyl-propyl-carbinol	119.5	0.809
Di-ethyl-carbinol	115.6	0.815
Methyl-isopropyl-carbinol	114	0.819
Tertiary butyl-carbinol	114	
Dimethyl-ethyl-carbinol	101.8	0.809

Data from International Critical Tables.

carbinol and secondary butyl-carbinol may be used in the Gerber test. Fusel oil, obtained as a by-product of ethyl alcohol fermentation, is principally a mixture of these two isomers.

Some chemical firms list "Amyl alcohol, from fusel oil, for milk analysis." This material is usually satisfactory, but it cannot always be relied upon. Not long ago, such a sample was purchased. Although it was labeled "Suitable for Milk Analysis," Gerber tests made with it averaged 1.5 per cent higher than the tests made by the Babcock method. At that time, three other lots of amyl alcohol were tested in the hope that one might be found which could be used in the determination of butterfat. All of the samples were of C.P. quality, but all gave tests which were 0.6 per cent, or more, greater than the values found by the Babcock method. These

Received for publication January 3, 1933.

examples are cited to show the importance of specifying the particular alcohol desired when ordering this reagent.

The best method of identifying any sample of amyl alcohol is by means of its boiling-point. The Fucoma Company specifies that the amyl alcohol used in the test should boil between 128° C. and 132° C. These specifications are doubtless satisfactory. A simpler method of testing the amyl alcohol has been used by some operators, who run the test using water instead of milk. Obviously, a good sample of alcohol should give no fat column at the end of the test. However, the reverse is not necessarily true. The amount of fat found when testing water is always less than the actual error caused by the alcohol. An alcohol sample which caused errors of 0.6 to 0.8 per cent in the fat test on milk, gave only 0.3 to 0.4 per cent of fat when tested with pure water. It is not improbable that samples of alcohol might be found which caused errors of 0.1 to 0.2 per cent, and which showed no oil layer, whatever, when tested with pure water.

THE COMPARATIVE VITAMIN A CONTENT OF NUT-MARGARINES AND BUTTER

CHARLES F. POE AND HAZEL A. FEHLMANN

Chemistry Department and State Food and Drug Laboratary, University of Colorado, Boulder, Colorado

During the past fifteen years, the consumption of cocoanut oil in the United States has increased very rapidly. In 1916, the nut-fats comprised only 3.1 per cent of the total fats used in the manufacture of oleomargarine. In 1929, this figure had increased to 43.6 per cent.

According to many investigators (1), there is little doubt that the energy value of nut-margarines, as well as their digestibility, is equal to that of butter. There does exist, however, some conflict as to the relative vitamin content of the two products. Butter is a very rich source of vitamin A, but most investigators claim that nut-margarines are deficient in this vitamin.

Halliburton and Drummond (2), Steenbock, Boutwell and Kent (3), and Fetter and Carlson (4) have each reported on one sample of nut-margarine. All these investigators agreed that the sample which they tested was low in vitamin A content. On the other hand, nut-margarines found on the market have been reported to contain vitamin A. One brand has been reported by Hawk (5) to contain as much vitamin A as butter. No statement, however, was made as to the source of the vitamin in this particular sample. In England, according to Coward (6), vitamin concentrates have been added to nut-margarines. A previous study (7) in this laboratory has shown that nut-margarines which contain palm oil will promote growth in white rats. The samples reported in that investigation showed from 10 to 15 per cent palm oil content. The vitamin A content, calculated in Sherman unit (8), ran from 0.65 to 4.7 units.

It was thought desirable to investigate the vitamin A content of a number of uncolored nut-margarines. Accordingly, a number of these products were purchased on the open market and submitted to biochemical tests.

The diet and procedures of the tests were the same as those used in the study of the colored margarines (7). After the white rats, all males, were depleted of their body-store of vitamin A, and their weight had become constant, their diet was supplemented with varying amounts of the different samples of margarine. Enough vitamin A-free peanut oil was added to the diet of each animal so that the fat constituent was 1 gram per day. Likewise, different levels of butter were fed to part of the animals, both pasteurized and unpasteurized samples being used. The diet used for the depletion period consisted of the following:

Received for publication February 15, 1933.

	PER CENT
Casein (Vitamin A-free)	18
Irradiated yeast, dried	7
Agar-agar, fine	2
Cornstarch	69
Salt mixture, Osborne and Mendel (9)	4

The experimental period lasted for eight weeks, and all tests were discontinued at the end of this time regardless of whether or not the animals were losing or gaining weight. The records of the growth curves of the

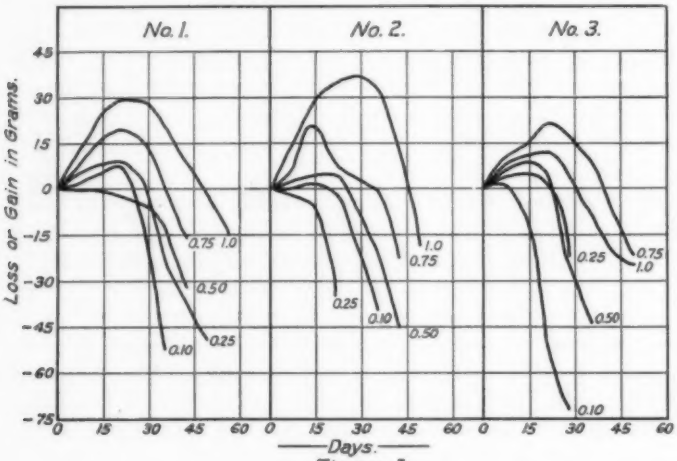


Figure I.

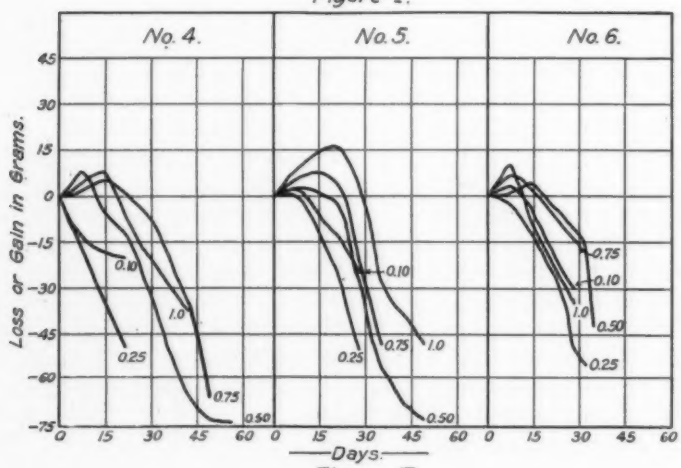


Figure II.

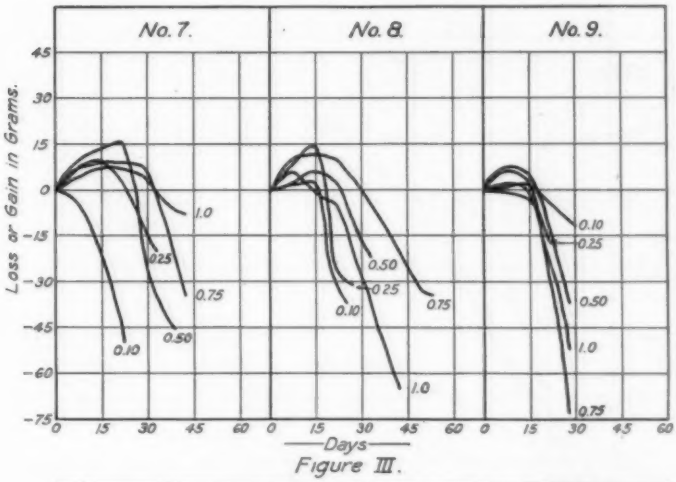


Figure III.

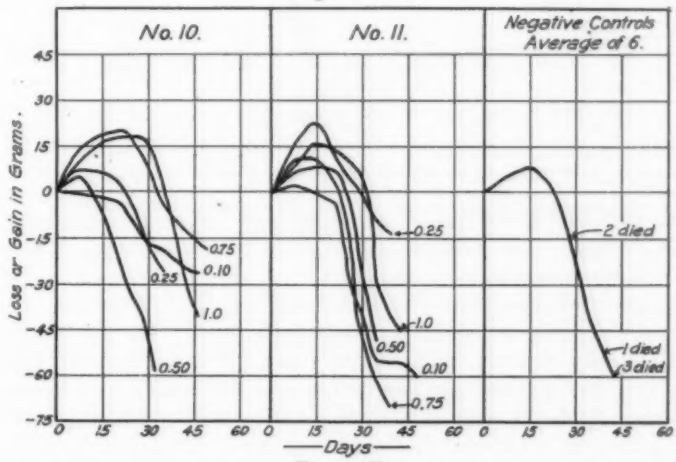


Figure IV

animals receiving the different levels of nut-margarine are given in figures I, II, III, and IV. The growth curves for two of the five animals receiving samples of butter are given in figure V.

The animals receiving the higher levels of margarines gained some weight during the first two or three weeks, but thereafter, in most cases, lost weight very rapidly. The highest daily level tested, namely 1 gram, was not sufficient to maintain growth during the experimental period. Only two animals were alive at the end of eight weeks and these were in very bad condition. One gram of nut-margarine failed to compare favorably with 1/20 that amount of butter.

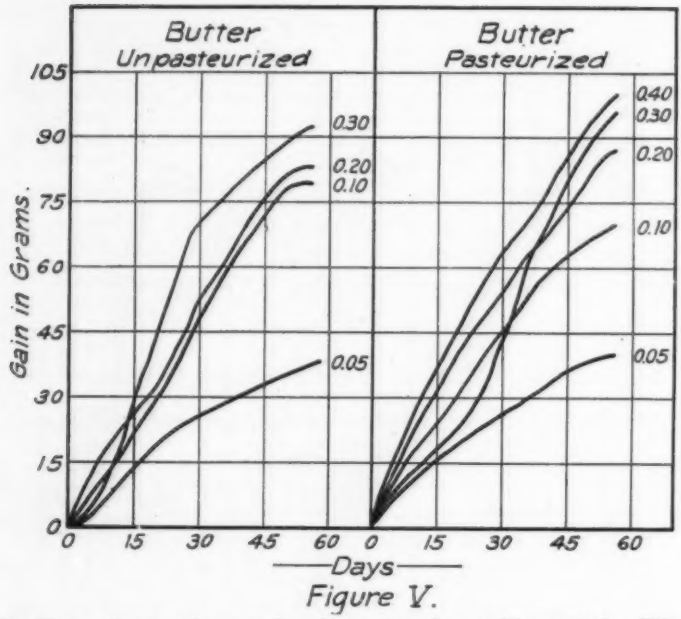


Figure V.

FIG. V gives the growth curves for white rats used as positive controls. Vitamin A was furnished by feeding different levels of butter. (Levels fed in grams.)

The fact that there was at first some gain in weight indicated some vitamin content. The gains in weight for a four-week-period were calculated. These are presented in table 1.

The growth curves for the animals receiving the different butters indicate a very rich source of vitamin A in these samples. The calculated units for the samples referred to in figure V were 33.3 for the unpasteurized butter and 31.7 for the pasteurized butter. The other three samples of pasteurized butter showed the following units: 40, 36, and 32.5. One unit as suggested by Sherman (8) is the amount of food product in grams necessary to produce an average gain of three grams per week during the test period of eight weeks. The above samples of butter were high in vitamin A units. Fraps and Treichler (10) have shown, however, that the vitamin A content varies with the food eaten by the cow. They found the butters which they assayed to run from 2 to 50 units of vitamin A to the gram.

A number of the samples of margarine seemed to vary in the amount of fat. It was thought that some information might be gained by a chemical analysis of the samples. The results of such an analysis are recorded in table 2. The margarines were made by churning the fats with milk.

TABLE 1

Table showing the gain in weight of animals at the end of a four-week-test period

NUMBER NUT-MARGARINE	GRAMS FEED	GAIN IN WEIGHT IN GRAMS	AVERAGE GAIN PER WEEK IN GRAMS
1	1.00	29	7.25
	0.75	16	4.00
	0.25	4	1.00
2	1.00	37	9.25
	0.75	4	1.00
3	1.00	4	1.00
	0.75	17	4.25
5	1.00	4	1.00
7	1.00	5	1.25
	0.75	8	2.00
8	0.75	3	0.75
10	1.00	18	4.50
	0.75	11	2.75
11	1.00	8	4.00
	0.25	2	0.50

Samples number 4, 6, and 9 showed a loss in weight for all levels feed at the end of four weeks.

TABLE 2

Chemical analyses of the different samples of nut-margarine

SAMPLE NUMBER	MOISTURE	FAT	CURD	ASH	SALT	SALT FREE ASH
1	13.50*	82.17	0.57	3.76	3.46	0.30
2	10.62	84.90	1.53	2.95	2.62	0.33
3	6.45	89.86	0.96	2.73	2.41	0.32
4	16.69	78.12	1.21	3.98	3.69	0.29
5	8.53	87.24	1.68	2.55	2.42	0.13
6	5.96	90.24	1.35	2.45	2.25	0.20
7	5.93	90.70	1.14	2.23	2.07	0.16
8	13.17	82.24	1.13	3.46	3.36	0.10
9	4.34	92.54	0.86	2.26	2.07	0.19
10	8.46	88.21	1.18	2.15	1.99	0.16
11	10.37	85.26	1.52	2.85	2.69	0.16

* Results expressed in per cent.

There was of course a certain amount of vitamin A in the milk used. Some of the growth of the animals on the higher levels during the first three or four weeks may have been due to the vitamin contained in the milk.

CONCLUSIONS

1. Nut-margarines, when compared with butter, seem to be an extremely poor source of vitamin A.

2. The variation in the fat constituent of the different samples seems to indicate the desirability of establishing standards for nut-margarines.

REFERENCES

(1) SNODGRASS, K. Margarine as a butter substitute. Chapter XIV. Food Research Institute, Stanford University. 1930.

(2) HALLIBURTON, W. D., and DRUMMOND, J. C. The nutritive value of margarines and butter substitutes with reference to their content of the fat-soluble accessory growth substance. Amer. J. Physiol. **51**: 235. 1917.

(3) STEENBOCK, H., BOUTWELL, P. W., and KENT, H. E. Fat-soluble vitamine I. J. Biol. Chem. **35**: 517. 1918.

(4) FETTER, DOROTHY, and CARLSON, A. J. Vitamin A and D content of some margarines. Amer. J. Physiol. **96**: 257. 1931.

(5) HAWK, P. B. Vitamin content of nut margarine. Amer. Food Jour. **19**: 379. 1924. Practical Physiological Chemistry. pp. 804–805, 9th ed.

(6) COWARD, KATHERINE H. Vitamin content of margarine. Lancet **1928** (2): 726.

(7) POE, C. F., and FEHLMANN, HAZEL A. Vitamin A content of naturally colored nut margarines. J. Ind. and Eng. Chem. **25**: 402. 1933.

(8) SHERMAN, H. C., and BURTIS, M. P. Factors affecting the accuracy of the quantitative determination of vitamin A. J. Biol. Chem. **78**: 671. 1928.

(9) OSBORNE, T. B., and MENDEL, L. B. The nutritive value of the wheat kernel and its milling products. J. Biol. Chem. **37**: 557. 1919.

(10) FRAPS, G. S., and TREICHLER, RAY. Quantitative variations in vitamin A content of butter fat. J. Ind. and Eng. Chem. **24**: 1079. 1932.

THE YIELD AND COMPOSITION OF MILK FROM ABERDEEN-ANGUS COWS[1]

L. J. COLE AND IVAR JOHANSSON

Department of Genetics, College of Agriculture, Madison, Wisconsin

Cows of the specialized beef breeds are seldom tested for milk production and consequently very little is known about the actual milk yield and its variation within these breeds. A search through the literature for data on the yield and composition of milk from purebred Aberdeen-Angus cows has given very meager results. Gowen (5, 6) has reported the milk yield of three Aberdeen-Angus cows from the Maine cross-breeding experiment. One cow produced in one year 2,852 pounds of milk, and two others produced in eight months 1,065.9 pounds of milk with 4.40 per cent of butterfat, and 1,569.3 pounds milk with 4.64 per cent butterfat, respectively. The average percentage of butterfat for the Aberdeen-Angus cows of the Maine experimental herd is said to be 4.4, with considerable range on either side of this point.

In the Aberdeen-Angus Review (8) some records on milk production have been published. It is obvious that these records cannot be considered as random samples of the breed but they show what some of the best milkers are able to produce under favorable conditions. In a Scotch Aberdeen-Angus herd twelve cows of different ages attained for one year an average of 7,866 pounds of milk with a range of variation from 5,750 to 11,340 pounds. The English Register of Dairy Cattle with Authentic Milk Records is also quoted. In 1927 six tested Aberdeen-Angus cows produced on an average 10,859 pounds of milk, and from an earlier volume of the Register an average for the same breed of 9,244 pounds milk is given. The number of cows in this latter case is not mentioned. One Angus cow from a Scotch herd produced 8,484 pounds of milk with 3.4 per cent of butterfat in thirty-seven weeks, and another cow gave during her first lactation 6,210 pounds of milk with 5.08 per cent butterfat. From a Canadian Aberdeen-Angus herd the records of two cows are mentioned; one produced 5,798 pounds and the other 5,371 pounds of milk in eight months. The butterfat percentages were 4.1 and 4.0, respectively. References are also made to daily yields showing that individual cows may attain a rather high rate of secretion. The butterfat content of the milk is in most cases above 4.0 per cent.

Received for publication February 23, 1933.

[1] Papers from the Department of Genetics, Wisconsin Agricultural Experiment Station, No. 151. Published with the approval of the Director of the Station.

Woll (9) refers to English milking trials with different breeds of cattle and gives an average daily production for tested Aberdeen-Angus cows of 60.3 pounds of milk with 4.99 per cent butterfat and 13.75 per cent total solids. Presumably only exceptional cows from the standpoint of milk production competed in these trials.

MILK PRODUCTION OF ABERDEEN-ANGUS COWS IN THE WISCONSIN CROSSBREEDING EXPERIMENT

An experiment in crossbreeding Aberdeen-Angus cattle to Jersey and Holstein-Friesian has been conducted since 1912 by the Department of Genetics, University of Wisconsin, in order to study the inheritance of milk production and beef characters. In this experiment lifetime records on milk production have been obtained for seven purebred Aberdeen-Angus cows. The butterfat percentage of the milk was determined once a week (Babcock test) on composite samples taken at each milking. During the early part of the experiment chemical analyses of the milk from each cow in the crossbreeding herd were made once in every four-week period. Samples were taken at each milking during three consecutive days in the second week of the period, and the composite sample was analyzed by the Department of Agricultural Chemistry according to the methods adopted by the Association of Official Agricultural Chemists. Also, the iodine (Hübl) number and Reichert-Meissl number of the butterfat were determined.

The cows in the crossbreeding herd have been stall-fed practically the whole year on hay, silage and a suitable concentrate mixture. Pasture and cut green feed have, however, in some cases been used to a minor extent during the summer. Milking has been made twice daily throughout the lactation period. The aim has been to keep the environment as constant as possible from year to year and for all cows in the herd.

The milk production of the seven tested Aberdeen-Angus cows should therefore allow a fair comparison with the production of the Jersey and Holstein-Friesian cows kept under the same conditions. In the early part of the experiment the herd became infected with contagious abortion, which caused irregularities in breeding of a number of cows. For the last ten years the herd has been free from this disease.

In table 1 a brief description is given of the Aberdeen-Angus cows used in the experiment.

The cows 3A, 4A, 16A and 18A are from the same stock and all closely related; 3A and 4A are half sisters on the sire's side, 16A is a daughter of 3A mated to a half brother, and 18A is a daughter of 16A. The other three cows, 32A, 35A and 36A, were bought from different herds and have no common ancestors in the first three ancestral generations. They were all from registered parents but not themselves registered due to the red

TABLE 1

Body measurements, live weight and type of the Aberdeen-Angus cows

COW	BODY LENGTH	WITHER HEIGHT	HEART GIRTH	LIVE WEIGHT	DIMENSION-WEIGHT INDEX	COLOR	TYPE
	cm.	*cm.*	*cm.*	*lbs.*			
3A	147.7	123.2	198.9	1320	3.56	Black	Good Angus type. A little course in shoulder and neck and light in hind quarter.
4A	141.8	115.6	191.5	1218	3.32	Black	Good Angus type but small. Udder well developed.
16A	145.1	122.0	198.0	1125	4.03	Black	Rather poor in type. Lacking in width of back and loin.
18A	141.0	120.0	194.2	1188	3.59	Black	Fairly good type, but lacking in depth.
32A	162.0	122.4	197.5	1226	4.13	Dark Red	Fairly good Angus type, but somewhat long in body and ribs not well sprung.
35A	163.9	130.7	209.4	1419	4.16	Dark Red	Rather poor type, long-bodied and lacking in depth.
36A	153.8	121.5	206.1	1356	3.55	Dark Red	Very good Angus type.

color. The body measurements and live weights stated in the table are determined in comparable stages of the lactation period, two to four months after calving, and at an age of at least three and one-half years. The dimension-weight index $I = \left(\frac{H^2 \times L}{W \times K}\right)$ is determined according to Yapp (10) on the basis of wither height (H), body length (L), live weight (W) and a constant (K) representing the volume of one pound body weight. A good type Angus cow has a comparatively low index.

In table 2 the milk records are presented for each Aberdeen-Angus cow in the experimental herd. On an average the cows have produced approximately 3,100 pounds of milk with 4.1 per cent of butterfat per lactation period, but with considerable variation around these figures. The cow 3A had the lowest production, 884.2 pounds of milk as an average for her three lactations, whereas 35A, the best milker, attained an average of 4,691.2 pounds of milk in the corresponding lactations. The average lactation yields of the purebred Jersey and Holstein-Friesian cows of the herd are presented for comparison. The number of animals of each breed is too small, and age at the first calving as well as the length of subsequent

TABLE 2

Milk production of pure bred Aberdeen-Angus, Jersey and Holstein-Friesian cows in the experimental herd

	FIRST LACTATION						
	AGE AT FIRST CALVING	TIME IN MILK	CALVING INTERVAL	MILK	BUTTERFAT		FAT CORRECTED MILK (4%) IN 180 DAYS
Aberdeen-Angus	*Yrs.-Mos.*	*Days*	*Days*	*Lbs.*	*Per cent*	*Lbs.*	*Lbs.*
3A	2– 5	184	327	1027.3	4.51	46.38	1103.2
4A	2– 8	214	293	1781.1	4.53	80.61	1730.0
16A	3– 9	.....	422		Not Milked		
18A	2– 1	285	343	2583.6	4.33	111.96	2061.6
32A	4–10	251	366	2764.2	4.43	122.48	2348.2
35A	2– 3	444	509	4657.5	4.28	199.27	2362.4
36A	2– 3	551	635	6746.1	4.48	302.38	3224.8
Average		321.5	412.2	3260.0	4.41	143.85	2138.4
Average for two Jersey cows		379.0	405.5	5801.9	5.11	296.54	3814.9
Average for six Holstein-Friesian cows		320.7	.....	8516.6	3.35	284.97	5242.7

	SECOND LACTATION					
	TIME IN MILK	CALVING INTERVAL	MILK	BUTTERFAT		FAT CORRECTED MILK (4%) IN 180 DAYS
Aberdeen-Angus	*Days*	*Days*	*Lbs.*	*Per cent*	*Lbs.*	*Lbs.*
3A	110	349	874.7	4.16	36.41	886.1
4A	266	306	2808.7	4.16	116.94	2616.7
16A	97*	293	295.5	4.34	12.82	.....
18A	140	.....	2259.5	3.89	87.95	.....
32A	206	321	3093.0	3.97	122.91	2943.9
35A	264	320	4880.9	3.84	187.49	3865.6
36A	191	.....	3712.9	4.10	152.06	3624.3
Average	196.2	.....	2938.2	3.99	117.29	2787.3
Average for two Jersey cows	313.5	338.5	5236.7	4.95	259.14	4437.3
Average for six Holstein-Friesian cows	312.8†	.....	8766.3	3.46	303.32	5497.5

	THIRD LACTATION					
	TIME IN MILK	CALVING INTERVAL	MILK	BUTTERFAT		FAT CORRECTED MILK (4%) IN 180 DAYS
Aberdeen-Angus	*Days*	*Days*	*Lbs.*	*Per cent*	*Lbs.*	*Lbs.*
3A	103	.....	750.6	4.00	30.05	.....
4A	329	404	3486.3	4.29	149.41	2771.8
16A	300	351	3472.8	4.52	157.04	2751.0
18A	.....	.....	.....	.....	.....	.....
32A	242	.....	3422.4	3.92	134.30	3025.1
35A	252	325	5225.3	4.14	216.11	4532.4
36A	.....	.....	.....	.....	.....	.....
Average	245.2	.....	3271.5	4.20	137.38	2766.3
Average for two Jersey cows	290	310	6503.8	4.79	311.36	5362.3
Average for six Holstein-Friesian cows	356‡	.....	10454.1	3.45	361.05	6073.2

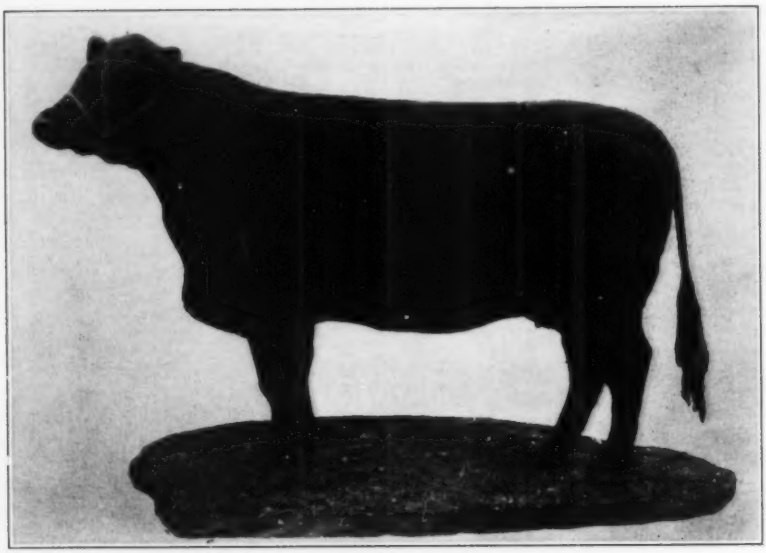
	FOURTH LACTATION					
	TIME IN MILK	CALVING INTERVAL	MILK	BUTTERFAT		FAT CORRECTED MILK (4%) IN 180 DAYS
Aberdeen-Angus	*Days*	*Days*	*Lbs.*	*Per cent*	*Lbs.*	*Lbs.*
3A	.....	.....	.....	.....	.....	.....
4A	.....	.....	.....	.....	.....	.....
16A	271	293	3409.9	4.15	141.40	2845.8
18A	.....	.....	.....	.....	.....	.....
32A	.....	.....	.....	.....	.....	.....
35A	228	354	2422.3	3.56	86.19	2090.8
36A	.....	.....	.....	.....	.....	.....
Average	245.9	323.5	2916.1	3.90	113.80	2468.3
Average for two Jersey cows	314.5	.....	5620.0	4.62	259.76	4175.4
Average for six Holstein-Friesian cows	324.5§	376	11541.5	3.73	429.93	7348.5

* Calf sucking part of the time. Not included in average.

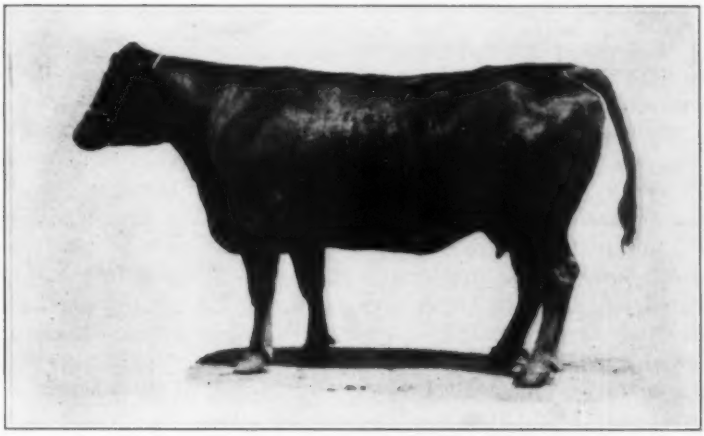
† Four cows.

‡ Three cows.

§ Two cows.



FIGS. 1–2. ABERDEEN-ANGUS COW 3A. MARCH 15, 1916. AGE 5 YEARS AND 5 MONTHS. GOOD ANGUS TYPE; A LITTLE COARSE IN SHOULDER AND NECK AND LIGHT IN HIND QUARTER.



FIGS. 3–4. ABERDEEN-ANGUS COW 35A. MAY 27, 1926. AGE 6 YEARS. RATHER POOR TYPE; LONG-BODIED AND LONG-LEGGED.

calving intervals are too varying, to make a general breed comparison possible, but the figures show what the cows of the experimental herd have accomplished under similar conditions of feeding and management. The Aberdeen-Angus cows were in the herd during their whole productive life and nothing was known about the milk producing ability of their ancestors. Making reservation for the blood relationship between these cows them-

selves they may therefore be considered as random samples of the breed as far as milk production is concerned.

In order to make a more fair comparison possible between the individuals and between the three groups representing different breeds the milk production is calculated for each cow during the first 180 days after calving, and the actual yield in this period is converted into milk of 4 per cent butterfat according to the method of Gaines and Davidson (3), *i.e.*, to milk of the same energy content per unit weight. The amount of fat corrected milk in 180 days is presented in table 2 for each lactation period. When the yields of the three groups of fat corrected milk in 180 days are compared the Aberdeen-Angus cows are unduly favored, to some extent, because they have normally a shorter lactation period than the other two groups of cows. In spite of the errors involved, the yield of fat corrected milk in 180 days probably conveys a truer picture of the inherent differences between the individuals and groups, as well as of the change in milk yield with increasing age of the cows, than do the averages for the total lactation yield.

In comparing the type descriptions of the Aberdeen-Angus cows (Table 1) with their milk records (Table 2) it may be noted that the most long-bodied and high-legged cow, 35A, was the best milker. The poorest milker, 3A, was of good Angus type, and her dimension-weight index indicates her to be rather blocky. For the other five cows the correlation between type and production is not so obvious; 36A was of very good Angus type and at the same time she was almost equal to 35A as a milker. It would not be justifiable, therefore, to draw any general conclusions regarding the correlation between beef characters and milk production on the basis of our limited data.

SHAPE OF THE LACTATION CURVE

The lower total lactation yield of milk from the Aberdeen-Angus cows than from the Jerseys and Holstein-Friesians is due partly to a lower rate of secretion, *i.e.*, a lower daily yield, and partly to a shorter lactation period. In table 2 the number of days in milk is given for each lactation period of the Aberdeen-Angus cows. The variation is to some extent due to variation in the interval between calving and succeeding pregnancy, but especially one of the cows, 3A, shows a very short lactation even when the service period is approximately normal, and the short lactations of this cow seem, therefore, to be an inherent characteristic.

Table 3 presents for each purebred Aberdeen-Angus, Jersey and Holstein-Friesian cow of the experimental herd the maximum milk yield in a four-week period for each of the first four lactations. The maximum yield is, as would be expected, highest for the Holstein-Friesians and lowest for the Aberdeen-Angus cows. Some of the Angus cows, *e.g.*, 35A, have, how-

TABLE 3

Maximum yield of milk in a four-week period, pounds

	1ST LACTATION	2ND LACTATION	3RD LACTATION	4TH LACTATION
Aberdeen-Angus				
3A	204.1	265.8	264.0	.....
4A	286.5	446.3	520.6	.....
16A	.....	.....	457.4	530.3
18A	366.4	.....	.....	.....
32A	430.1	632.0	688.2	.....
35A	416.2	749.3	815.4	681.4
36A	555.1	620.9	.....	.....
Average	376.4	542.9	549.1	605.9
Jersey				
5A	733.0	1023.7	1153.7	955.4
6A	448.1	503.6	733.3	727.2
Average	590.6	763.7	943.5	841.3
Holstein-Friesian				
34A	1033.2	.....	.....	.....
40A	834.9	1249.0	1190.4	1259.1
45A	1073.7	798.7	948.0	1356.2
52A	892.7	1034.4	.....	.....
60A	957.7	1207.3	1500.4	.....
81A	1151.4	.....	.....	.....
Average	990.6	1072.4	1212.9	1305.2

ever, attained a fairly high maximum yield, showing a reasonably good rate of milk secretion. It is probable that with three milkings daily the difference in maximum yield between the Holstein and Angus cows would have been still greater.

Attempts have been made to find a suitable numerical measure for the persistency of milk secretion. With a wide variation in the calving interval and in other factors influencing the shape of the lactation curve, any such numerical measure seems, however, to fail in describing the presumably existing inherent differences between the animals. Sanders' (7) shape figure, Gaines' (4) exponential constant, or Bruun's (1) coefficient of variation do not disclose any differences in persistency among the three groups of cows studied.

Figures 5 and 6 give some general idea of the distribution of the milk yield in the first lactation period of the Aberdeen-Angus and Holstein-Friesian cows of the experimental herd.

The diagrams are based on figures for four Angus and five Holstein cows which have not been in milk more than 365 days. The records for

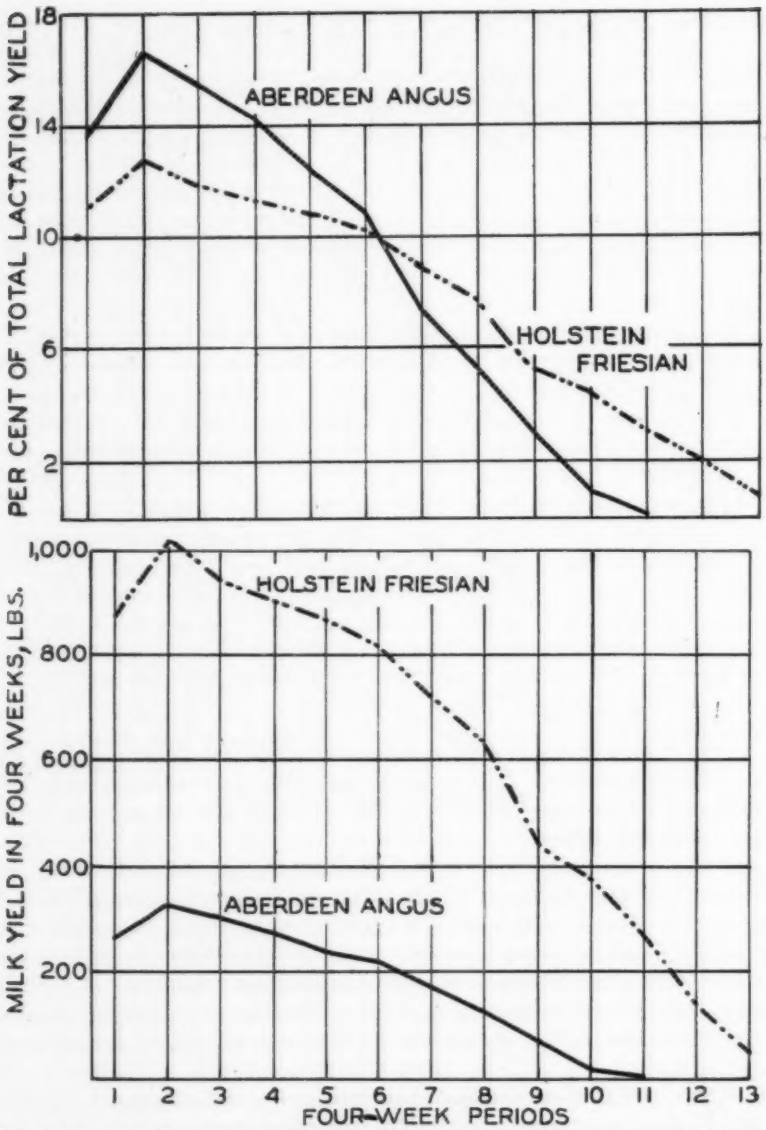


FIG. 5 (LOWER). LACTATION CURVES FOR THE FIRST LACTATION PERIOD OF FOUR ANGUS AND FIVE HOLSTEIN COWS.

FIG. 6 (UPPER). PERCENTAGE DISTRIBUTION OF THE LACTATION YIELD OF MILK IN FOUR-WEEK PERIODS.

the Jersey cows are not comparable and are therefore excluded. Due to a shorter period in milk a larger percentage of the total lactation yield is produced during the early months of lactation in the Angus than in the Holsteins (Fig. 6). A short lactation period and a low rate of secretion seem to be characteristic of the Aberdeen-Angus cows of the experimental herd.

COMPOSITION OF THE MILK

The results of the chemical analyses of the milk are presented in table 4. All Aberdeen-Angus cows for which analyses were made, are included and also, for comparison, the two Jersey cows. No analyses were made of the milk from the Holstein-Freisian cows. The figures presented in the table are averages for the first six analyses after calving, covering approximately six months of the lactation period. The time interval between calving and the taking of sample for the first milk analysis was at least one week.

A separate study has been made of the correlation between composition of the milk and age of the cow. The fat percentage shows a consistent, although slight decrease with increasing age of the cow, and there is a tendency for the percentage protein to behave similarly, whereas the other milk constituents seem to be unaffected. For more reliable comparison the group averages in table 3 are calculated for corresponding lactation periods.

The milk from the two Jersey cows of the experimental herd has a somewhat higher content of fat and protein and consequently a higher percentage of total solids than the milk of the Aberdeen-Angus cows. The percentage of ash and milk sugar is practically the same and in the iodine number and Reichert-Meissl number of the butterfat there is no significant difference. Within the group of four Aberdeen-Angus cows there is some variation in the composition of the milk, but this variation is rather small. The variation in the iodine number of the butterfat is more pronounced. The cow 4A dropped both her second and third calves in the spring, and the high iodine number of her butterfat is probably due to grass feeding during the summer. The cows 16A and 18A calved in November and January, respectively, and they received dry feed and silage exclusively during the first six months after calving. The second lactation of 3A covered February to March and the third January to April, all her lactation periods being very short. She received no green feed during either of the lactations, but especially for the second lactation the iodine number of the buterfat is rather high. It would, however, not be safe to draw any conclusions regarding individual differences between the cows in the composition of butterfat on the basis of the data available.

An attempt was made to secure accurate measurements of the differences in color of the Angus and Jersey milk, but the results were unsatisfactory. Angus milk is much lighter in color than Jersey milk and butter

TABLE 4

Composition of milk from three Angus and two Jersey cows. The figure for each lactation is the average of six analyses at four-week intervals during the first 180 days after calving

		SPEC. GRAVITY	TOTAL SOLIDS	FAT	PROTEIN	CASEIN	ASH	MILK SUGAR	HUBL NO.	REICHERT-MEISSL NO.
			per cent	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*
Aberdeen-Angus										
3A	2nd lactation	1.0330	12.97	4.03	3.75	2.83	0.658	4.78	38.52	25.55
	3rd "	1.0344	13.03	3.95	3.85	2.90	0.735	4.88	34.39	25.77
4A	2nd "	1.0333	13.07	4.01	3.36	2.63	0.663	5.20	37.33	29.78
	3rd "	1.0333	12.97	4.17	3.34	2.47	0.678	4.74	39.26	27.40
16A	3rd "	1.0330	13.67	4.15	3.50	2.70	0.657	5.15	30.33	28.61
18A	1st " *	1.0323	13.64	4.06	3.42	2.77	0.682	5.09	34.94	29.46
Average		1.0334	13.14	4.06	3.56	2.71	0.678	4.95	35.97	27.42
Jersey										
5A	2nd " †	1.0331	13.17	4.31	3.41	2.90	0.643	4.87	31.96	30.78
	3rd "	1.0356	13.33	3.98	3.99	2.97	0.662	4.62	31.35	30.02
6A	2nd "	1.0345	15.11	4.84	4.11	3.31	0.692	5.17	35.93	24.64
	3rd "	1.0352	14.26	4.68	3.91	3.11	0.680	5.18	34.81	29.32
Average		1.0351	14.23	4.48	4.00	3.13	0.678	4.99	34.03	27.99

* Analyses for three four-week periods only. Not included in average.
† Not included in average.

made from it is almost white as compared with the recognized yellow color of Jersey butter. For a description of fat-globule size of Angus milk see Campbell (2).

DISCUSSION

The records from the Maine and Wisconsin Experiment Stations show that the milk production of the average Aberdeen-Angus cow is rather low but also that the milk has a comparatively high content of fat and proteins. Some cows may be such low producers that they do not yield enough milk for the nourishment of the suckling calf. Records from British and Canadian cow testing associations indicate, however, that within the breed cows may be found which are very good milkers. It seems quite probable, therefore, that the average milk production of the breed could be considerably improved by selection. Whether this could be done without sacrificing anything of the beef qualities is, however, an open question.

The early development of the beef animal depends, to a large extent, upon the milk production of the mother, and the yield and composition of milk is therefore a matter of considerable practical importance. The Aberdeen-Angus is a specialized beef breed, and it may be questionable if within such a breed a higher milk production than needed for a good nourishment of the calves is desirable. A selection of breeding animals on the basis of actual figures for milk production might conceivably focus the attention too much upon the milk records and thus divert it from the main purpose of beef breeds, *viz.*, the production of meat. In many herds, from which breeding stock is sold, it is, however, rather common to use nurse cows for the calves when their mothers are poor milkers, and this practice will undoubtedly in the long run tend to decrease the milk production of the cows below the requirements of the calves. The most desirable balance between meat and milk in a specialized beef breed can probably be obtained if the performance of the cows is measured on the basis of the development of the calves when they do not get any more milk than that produced by the mother. Cows that secrete less milk than required by their calves for normal development do not reach this standard, and a larger production of milk than the calf is able to utilize would be superfluous.

SUMMARY

Total lactation yield of milk and butterfat as well as butterfat percentage and milk analyses are presented for successive lactations of seven purebred Aberdeen-Angus cows from the experimental herd of the Department of Genetics, University of Wisconsin. On an average the cows have produced 3,100 pounds of milk with 4.1 per cent of butterfat per lactation but, especially in milk yield, there is a considerable range of variation around the average. The fat and protein content of the milk is a little

lower than in the milk from two Jersey cows kept under similar environmental conditions but the percentage of ash and milk sugar is practically the same. The rate of milk secretion is, on an average, lower in the Aberdeen-Angus cows than in the Jerseys and Holstein-Friesians of the same herd, and the lactation period is shorter. Some Aberdeen-Angus cows attain, however, as high monthly yield as low or medium producing Jerseys and show also a fairly good persistency of production.

REFERENCES

(1) Bruun, E. Factors influencing the lactation curve and the hereditariness of its shape in East Finnish cattle. (In Finnish with an English Summary), 137 pp. The Finnish Agr. Exp. Station, Dickursby, Finland. 1928.

(2) Campbell, M. H. A study of the fat-globule size in milk. Vermont Agr. Exper. Sta. Bull. 341. 1932.

(3) Gaines, W. L., and Davidson, F. A. Relation between percentage fat content and yield of milk. Illinois Agr. Exp. Station Bul. 245. 1923.

(4) Gaines, W. L. Persistency of lactation in dairy cows. Illinois Agr. Exp. Station Bul. 288. 1927.

(5) Gowen, J. W. Studies in inheritance of certain characters of crosses between dairy and beef breeds of cattle. Jour. Agr. Res. 15: 1–57. 1918.

(6) Gowen, J. W. Inheritance in crosses of dairy and beef breeds of cattle. Jour. Hered. 11: 300–316, 365–376. 1920.

(7) Sanders, H. G. The analysis of the lactation curve into maximum yield and persistency. Jour. Agr. Sci. 20: 145–185. 1930.

(8) The Aberdeen-Angus Review: No. 10, 1923, pp. 6–10; No. 17, 1927, pp. 25–26; No. 18, 1927, pp. 13–15; No. 19, 1928, pp. 22–23; No. 27, 1932, pp. 47–48.

(9) Woll, F. W. A Handbook for Farmers and Dairymen. 438 pp. New York. 1903.

(10) Yapp, W. W. A dimension-weight index for cattle. Amer. Soc. of Animal Production, Record of Proc. 1923, pp. 50–56. 1924.

Founders of The Official Dairy Instructors Association, 1906. Later, The American Dairy Science Association

Front row, seated

1. C. C. Hayden, Ill.
2. J. W. Decker, Ohio
3. C. F. Doane, U. S.
4. W. J. Fraser, Ill.
5. H. A. Hopper, Ill.

Middle row, standing

6. J. M. Truman, Ill.
7. C. H. Eckles, Mo.
8. E. H. Webster, U. S.
9. A. C. True, U. S.
10. H. H. Dean, Ont.
11. C. B. Lane, U. S.
12. Fred Rasmussen, Iowa

Back row, standing

13. C. E. Lee, Ill.
14. O. F. Hunziker, Ind.
15. E. S. Guthrie, Ohio
16. H. E. Van Norman, Pa.
17. Chas. Thom, U. S.
18. Eugene Davenport, Ill.
19. B. D. White, U. S.

THE FORMATION OF THE AMERICAN DAIRY SCIENCE ASSOCIATION[1]

WILBER J. FRASER

Dept. of Dairy Husbandry, College of Agric., Urbana, Illinois

The American Dairy Science Association was organized at the University of Illinois on July 17, 1906, in Morrow Hall, the room in which we are now meeting. The Association at that time was called the National Association of Dairy Instructors and Investigators.

Dairying was not considered as a separate phase of instruction in any of our agricultural colleges until about 45 years ago. Before that little instruction in dairying was given. In 1896 when I organized the dairy department in this university there were few dairy departments in the United States.

At that time the milk supply of Chicago was produced almost entirely by dual-purpose cows commonly called Durhams, there being few strictly dairy cows even in the intensive dairy region. These cows were poorly fed and there was little realization or appreciation of the great difference in profit from high over low-producing dairy cows.

To increase interest in improved and more economical dairying we secured the services of Mr. A. J. Glover, now editor of *Hoard's Dairyman*, to come to Illinois in 1901 and take up work in the herds to show the variation in production of different dairy cows and also to collect data upon various methods of procedure in milk production. To show how little interest was taken in this work, after three months of hard, conscientious work in the field, he did not have a single herd, the owner of which was willing to have his cows tested for production at no expense to himself.

The first 1,200 cows from which yearly records were secured in this way averaged only 5,521 pounds of milk and 219 pounds of fat, only $\frac{2}{3}$ of what the cows now in Dairy Herd Improvement Associations produce. One farmer whose herd Mr. Glover tested fed corn stover, timothy, and corn nubbins, and attributed the poor, unthrifty condition of his cows to "hollow horn" or "wolf-in-the-tail" and actually split the tail of each cow and tied in a piece of salt pork as a remedy for this serious evil.

The condition of the milk when it reached Chicago was not much better than that of the cows producing it. Any milk passed that was not actually sour or that had not been diluted with water. A considerable part of the milk consumed was delivered by small distributors having only one or two wagons. The milk was dipped from the can and poured into a pail or pitcher for the housewife.

[1] This article is a portion of an address given at the last annual convention of the American Dairy Science Association.

Thirty years ago we induced Professor J. M. Trueman, of Cornell University, to come here and investigate the condition of the milk supply of the cities of Illinois. Taking samples of milk as it was served on the tables of different hotels and restaurants in Chicago, he found that it was not only low in fat, frequently having had the cream partially removed, but even in the best hotels where a dinner cost $1.25, a considerable amount of unappetizing black sediment was frequently found in the bottom of the glass.

When this association was organized 27 years ago little attention was given to disease control in our dairy herds. Much money and skill were used in building up high-producing herds only to have them destroyed later by disease. One county near Chicago containing 60,000 dairy cows had 86 per cent react on the initial test for tuberculosis.

At that time purebreds were so much better than grades that they were highly regarded even without records. It was generally thought that a purebred bull was all that was necessary to improve a herd. Michigan had the only Dairy Herd Improvement Association in the country.

Little was known about the nutritional value of proteins and the importance of legumes as an economical feed for dairy cattle.

Nothing was known about vitamins, and the great value of minerals and proteins of milk was little appreciated as human food. The bacterial count in the general milk supply at the time the association was organized, was tremendous.

Milk as a means of carrying disease was not controlled as it is at present. Pasteurization was not required or generally practiced. Big epidemics of septic sore throat in Boston and Chicago two and six years after this brought pasteurization to the fore.

Various kinds of important milk drinks had not yet come into being. There never had been a National Dairy Show and the National Dairy Council had not yet been formed. Looking at it from our present-day knowledge, comparatively little was known about the whole field of better dairying, scientifically as well as practically.

The rapid growth of cities during the last 40 years had caused a greater demand for dairy products and developed many important problems both on the dairy farm and in the factory. Solving these problems was imperative for the health of the consumer and the advancement of the dairy industry.

The dairy departments in most states were small, and each was working largely by itself upon whatever problems seemed best from the local viewpoint. Many of these problems were of course not local, but of general interest to the whole country. Men from different states needed to get together to agree on how better methods could be put into practice, including official testing.

There seemed an urgent need to bring together the dairy science workers from all over the country and organize an association for the advancement of dairying and the dissemination of the important knowledge which we did possess. With this in mind, I called a meeting of all the dairy instructors and investigators of the United States and Canada here at the University of Illinois during the Graduate School of Agriculture in 1906. A total of 12 men from outside the state came, and these, with the 5 men then in this department, formed the association and became the charter members.

Of these 17, five have passed on: C. H. Eckles, of Minnesota, E. H. Webster and C. B. Lane, of the Dairy Division of the United States Department of Agriculture; F. R. Rasmussen, then of Iowa; and J. W. Decker, of Ohio State University. Of the 12 now living, 9 are unable to be present at this meeting and sent regrets. They are: Professor H. H. Dean, who for nearly 42 years had charge of the Dairy Department at Guelph, Ontario, and was retired from active service last summer; Dr. Charles Thom, then doing research work in soft cheese for the Dairy Division of the United States Department of Agriculture and now with the Bureau of Chemistry; Mr. B. D. White, then in butter work with the Dairy Division of the United States Department of Agriculture and now enjoying life on his farm in Minnesota; Professor C. F. Doane, then in cheese work in the Dairy Division of the United States Department of Agriculture, and now located in Portland, Oregon; Professor J. M. Trueman, then engaged in city milk supply work in this department and now professor of agriculture at Turo, Nova Scotia; Professor C. E. Lee, then in manufacturing work in this department and now with Gridley Dairy Company, Milwaukee, Wisconsin; and Professor E. S. Guthrie, then at the Ohio State University and now at Cornell; Professor H. A. Hopper, then of this department, and now in the Department of Animal Husbandry at Cornell. The other charter members who had a hand in the organization of this association and whom we are most happy to have with us to-day are: Professor O. F. Hunziker, then in charge of the Dairy Department in Indiana, and now conducting the research work for the Blue Valley Creamery Company of Chicago; Professor H. E. Van Norman, then in charge of the Department of Dairy Husbandry at Pennsylvania State College and now manager of the Dairy exhibit at the Century of Progress in Chicago; Professor C. C. Hayden, then of this department and now Head of the Dairy Department at the Ohio Experiment Station.

In the formation of any new organization some time necessarily is spent in getting bearings and charting the course best to follow. In going through the trial and error state, much time was consumed in controversy over such subjects as the addition score card, which never has worked and

never can be made to work because the principle upon which it is based is fundamentally wrong.

One of the helpful results that grew out of this first meeting and that should be emulated in all our meetings and work, is the spirit of inquiry. I remember reporting the work we had been doing for nearly ten years on the difference in efficiency of individual dairy cows when reduced to a like feed basis. Professor Eckles asked what was the exact cause of this great difference. No one was able to answer. Professor Eckles again asked if it was not the purpose of this society to find out. Receiving no satisfactory answer to this important question after speaking three times on the subject, he proceeded on his return home to figure out a method of doing this, and in connection with O. E. Reed conducted the experiment and later reported the results in Missouri Research Bulletin 2. From both the scientific and economic standpoint, this, in my opinion, is one of the most valuable contributions made by anyone working in the dairy field. The spirit of inquiry, which was so typical of Professor Eckles, should always be the guiding spirit of this association.

PROCEEDINGS OF THE 28TH ANNUAL MEETING OF THE AMERICAN DAIRY SCIENCE ASSOCIATION

The 28th Annual Meeting of the American Dairy Science Association was held on the campus of the University of Illinois, at Urbana, on June 26, 27, 28 and 29. The attendance at the meeting was surprisingly good, considering the times. A great majority of those in attendance came in their cars and many brought their families along.

The ladies were entertained by the ladies of the faculty of the Dairy Staff.

The afternoon of the 26th was devoted to judging demonstrations of dairy cattle and dairy products. On the evening of the 26th there was a large attendance of a meeting of the Breeds Relation Committee.

One afternoon was given over to a tour of the buildings and campus of the University. The group greatly enjoyed a garden party as the guests of Dean and Mrs. H. W. Mumford on the evening of the 28th.

One of the features of the banquet at the Urbana Country Club was the presentation of a scroll to Professor W. J. Fraser setting forth the appreciation of the association of Professor Fraser's vision and initiative in calling the meeting at Urbana in the summer of 1906 that resulted in the organization of the Official Dairy Instructors Association, which later became the American Dairy Science Association.

On Wednesday morning a memorial service to the late Doctor C. H. Eckles was held under the auspices of the Eckles Club. Doctor Eckles was one of the charter members of the association and served several terms as its President.

The Program Committee again published an excellent volume of abstracts of the papers presented on the program. Copies of these abstracts are still available and may be secured from Doctor H. A. Ruehe, Dairy Department, University of Illinois, Urbana, Illinois, for $1.00 a copy.

The following program was presented:

GENERAL SESSIONS

Tuesday, June 27, 1932—Morrow Hall, Old Agriculture

H. C. JACKSON, President, American Dairy Science Association, presiding.

Address of Welcome—Dean H. W. Mumford, College of Agriculture, University of Illinois.

President's Address—President H. C. Jackson, University of Wisconsin.

The Association: Its Founding, Achievements and Responsibilities—Wilber J. Fraser, University of Illinois.

Calcifying Action of Lactose—Julia Pratt Outhouse and Janice Smith, University of Illinois.

Codliver Oil and Tomatoes in Our Cottonseed Meal Studies—A. H. Kuhlman, Earl Weaver, and W. D. Gallup, Oklahoma A. and M. College.

The Vitamin D Contact of Corn Silage—H. E. Bechtel, C. W. Duncan, and C. F. Huffman, Michigan State College.

Vitamin D in Butter—T. M. Olson, South Dakota State College.

The Vitamin D Sparing Action of Magnesium in the Ration of Cattle—C. F. Huffman and C. W. Duncan, Michigan State College.

Vitamin A Content of Jersey and Holstein Cream—I. L. Hathaway and H. P. Davis, University of Nebraska.

The Relative Efficiencies of Irradiated Ergosterol and Irradiated Yeast for the Production of Vitamin-D Milk—W. E. Krauss and R. M. Bethke, Ohio Agricultural Experiment Station.

Should the Mineralization and Vitaminization of Milk Become General?—W. E. Krauss, Ohio Agricultural Experiment Station.

Thursday, June 29, 1933—103 New Agriculture

H. C. JACKSON, presiding

Business meeting.

EXTENSION SESSION

Tuesday, June 27, 1933—127 New Agriculture

C. R. GEARHART, Section Chairman, presiding

A Balanced Dairy Extension Program—O. E. Reed, Bureau of Dairy Industry, U. S. D. A.

Use of the Film Strip in Presenting a Dairy Extension Program—D. M. Seath, Kansas State Agricultural College.

Extension Work Through the Press—E. M. Harmon, *Successful Farming*.

How Kansas Has Presented a Milk Utilization Campaign—J. W. Linn, Kansas State Agricultural College.

Preliminary Studies of the Use of Lactation and C. T. A. Year Records—J. L. Lush and E. N. Shultz, Iowa State College.

Methods of Conducting Feeding Meetings—C. L. Blackman, Ohio State University.

Cooperative Testing with Vocational Agricultural Schools—A. J. Cramer, University of Wisconsin.

Possibilities of the Wider Use of Radio in Dairy Extension Programs—G. G. Gibson, Iowa State College.

Business Meeting—Reports of following Committees:

Committee on Better Sires—James W. Linn, Kansas State Agricultural College.

Committee on Testing—R. T. Harris, University of Wisconsin.

Committee on Feeding—M. J. Regan, University of Missouri.

INSTRUCTION SESSION

Tuesday, June 27, 1933—103 New Agriculture

R. B. STOLTZ, presiding

Coordinating Method and Subject in Courses Presented by the Department—Earl Weaver, Oklahoma A. and M. College.

Content and Method of Presentation of Dairy Cattle Management Courses—H. P. Davis, University of Nebraska.

Content and Method of Presentation of Subject Matter in a Six-Months' Creamery Short Course—F. L. Richart, University of Nebraska.

Suggested Content and Methods of Presentation of a Course in the Analyses of Dairy Products for Advanced Students—L. K. Crowe, University of Nebraska.

Two-Year Non-Collegiate Course in Dairy Industry—E. F. Goss, Iowa State College.

Mathematics Pertaining to the Industry of Dairy Manufacturing—R. B. Stoltz and F. P. Frutchey, Ohio State University.

Teaching and Content of a Course in Milk Secretion—C. W. Turner, University of Missouri.

Fewer Breeds in College Dairy Herds—Earl Weaver and P. C. McGilliard, Oklahoma A. and M. College.

Some Fundamental Research Techniques—H. P. Davis, University of Nebraska.

Building College Curricula—C. R. Griffith, University of Illinois.

Recreation Hour.

Reception for members and guests by Dean H. W. Mumford, South Campus.

DAIRY MANUFACTURES SESSIONS

Wednesday, June 28, 1933—103 New Agriculture

J. O. BARKMAN, Section Chairman, presiding

Some of the Factors Affecting the Body, Texture, and Quality of Ice Cream—B. E. Horrall, Purdue University.

Vitamin C Retention in Frozen Pack Strawberries and Strawberry Ice Cream—C. R. Fellers and M. J. Mack, Massachusetts State College.

A Study of Proposed Gelatin Substitutes in Ice Cream—P. S. Lucas and Ira Gould, Michigan State College.

Macroscopic Study of the Crystalline Structure of Different Ice Creams—W. H. E. Reid, University of Missouri.

A Rapid Method of Determining Charge and Hydration of Protein Particles in Ice Cream Mixes—J. I. Keith and T. R. Freeman, Oklahoma A. and M. College.

Aging Effect on Gelatin Dispersions—W. S. Mueller, Massachusetts State College.

Some Observations on the So-Called Tallowy Flavor of Strawberry Ice Cream—O. E. Ross, E. W. Bird, and C. A. Iverson, Iowa State College.

Development of Off-Flavors in Strawberry Ice Cream—R. J. Ramsey and P. H. Tracy, University of Illinois.

Relation of Total Acidity and pH of Ice Cream, Sherbet and Ices—A. C. Dahlberg and J. C. Hening, New York Agricultural Experiment Station, Geneva, New York.

The Effect of Sodium Caseinate Sols on the Whipping Ability, Body and Texture, and the Flavor of Ice Cream—H. W. Sadler, E. W. Bird, and C. A. Iverson, Iowa State College.

Business Session.

Tour of Campus and Experiment Station. Meet at 103 New Agriculture.

Thursday, June 29, 1933—103 New Agriculture

J. O. BARKMAN, Section Chairman, presiding

Studies of Factors Influencing the Induction Period in the Oxidation of Milk Fat—J. L. Henderson and C. L. Roadhouse, University of Calfiornia.

The Effect of Cooling Milk Over a Surface Cooler on the Flavor; Cream Line; and Evaporation Loss—H. J. Leach and W. H. Martin, Kansas State Agricultural College.

Studies in Cream Whipping—H. L. Templeton and H. H. Sommer, University of Wisconsin.

Comparison of the Nutritive Value of the Protein of Cheese and Rennet Curd—H. H. Mitchell, University of Illinois.

The Control of Brick Cheese Manufacturing Operations with Special Cultures—A. B. Erekson, E. G. Hastings, and W. V. Price, University of Wisconsin.

Technical Control of Brick Cheese Manufacturing Operations—F. E. Hanson and W. V. Price, University of Wisconsin.

Cheese Spreads or Cheese Food Compounds—H. L. Templeton and H. H. Sommer, University of Wisconsin.

A Method for the Manufacture of "Sweet Curd" Cottage Cheese—J. I. Keith, E. L. Fouts and K. W. Knechtel, Oklahoma A. and M. College.

The Relation of the Cospora Lactis to the Keeping Quailty of Butter—O. H. Ause and H. Macy, University of Minnesota.

Relation of the Composition of Butterfat to the Churnability of Cream—S. T. Coulter and W. B. Combs, University of Minnesota.

Experiments with the Reductase Test for Grading Cream—H. Macy, University of Minnesota.

A Year's Measurement of Improvement in Butter Quality from the Four-Day Plan of Buying Cream—H. B. Morrison, J. O. Barkman, University of Kentucky, and J. A. Britt, City Consumers' Company, Paducah, Kentucky.

The Occurrence of Crumbly Butter—W. B. Combs and S. T. Coulter, University of Minnesota.

The Electrokinetic Potential and Its Relation to Churning—G. C. North and H. H. Sommer, University of Wisconsin.

Bacteria Associated with Roquefort Flavor in Butter—E. O. Herreid and H. Macy, University of Minntsota.

X-Ray Examination of Dairy Products—S. L. Tuckey and H. A. Ruehe, University of Illinois.

Effect of the Amount and Strength of Phenolphthalein Indicator Used in Determining the Titratable Acidity of Milk—L. H. Burgwald, Ohio State University.

The Titratable Acidity and pH of Milk at the Curdling Point at Various Temperatures—H. H. Sommer, University of Wisconsin.

The Importance of Metals in the Manufacture of Condensed Milk Products—Z. D. Roundy and H. C. Jackson, University of Wisconsin.

Rubber *vs.* Copper as a Material for Vacuum Pans from the Standpoint of Tallowy Flavor Development in Condensed Milk—J. H. Erb, Ohio State University.

Detection of Mastitis in Milk—B. E. Horrall, Purdue University.

PRODUCTION SESSIONS

Wednesday, June 28, 1933—127 New Agriculture

J. H. HILTON, Section Chairman, presiding

The Functional Development of the Mammary Gland—W. U. Gardner and C. W. Turner, University of Missouri.

The Effect of Certain Factors on the Persistency of Milk Secretion—L. C. Gilmore, H. L. Ibsen, and H. W. Cave, Kansas State Agricultural College.

Influence of Pregnancy Upon the Gain in Weight in Lactating Dairy Cows—R. F. Morgan and H. P. Davis, University of Nebraska.

Selecting Herd Sires—A. L. Darnell, Texas A. and M. College.

Daughter-Dam Correlations When Records Are Made Under Standard Conditions—W. E. Petersen, University of Minnesota.

Is a Cow's Own Record or the Average Record of Her Daughters the Most Accurate Indicator of Her Genotype?—J. L. Lush, Iowa State College.

Business Meeting, Production Section.

Report of Committee on Evaluation of Proven Sires. Discussion.

Tour of Campus and Experiment Station. Meet at 103 New Agriculture.

Thursday, June 29, 1933—103 New Agriculture

J. H. HILTON, Section Chairman, presiding

The Antirachitic Value of Green, Artificially Dried and Sun-Cured Pasture Herbage—R. E. Hodgson and J. C. Knott, Washington State College.

The Digestion and Energy Metabolism of Phosphorus Deficient Dairy Cattle—W. H. Riddell, J. S. Hughes, and J. B. Fitch, Kansas State Agricultural College.

Mineral Deficiencies Occurring in the Rations of Calves Under Farm Conditions—T. W. Gullickson, University of Minnesota.

Effect of Calcium Deficient Roughages Upon Milk Yield and Bone Strength in Cattle—R. B. Becker and W. M. Neal, Florida Agricultural Experiment Station.

Rock Phosphate Fed at Various Levels as a Mineral Feed for Dairy Cattle—G. Bohstedt, E. B. Hart, and P. H. Phillips, University of Wisconsin.

Silage Without Hay for Dairy Cows—C. C. Hayden, C. F. Monroe, and A. E. Perkins, Ohio Agricultural Experiment Station.

Corn Silage as a Sole Source of Roughage for Dairy Cows—C. Y. Cannon, D. L. Espe, and H. W. Goble, Iowa State College.

Relation of Season to Increase in Weight of Dairy Heifers—D. L. Espe and C. Y. Cannon, Iowa State College.

Studies on the Fat Content of the Blood of Dairy Cattle—Nat N. Allen, University of Minnesota.

The Effect of Soybeans on the Butterfat Content of Milk—J. W. Wilbur, Purdue University.

The Sampling of Milk for Testing Where a Combine Milker Is Used—H. A. Herman, University of Missouri.

Influence of the Plane of Production on Water Consumption of High-Producing Dairy Cows—F. W. Atkeson and T. R. Warren, University of Idaho.

Water *vs.* No Water in the Feeding of Dairy Calves When on Skim Milk—G. A. Bowling and R. A. Ackerman, West Virginia University.

Dairy Pasture Returns—J. P. LaMaster, C. D. Grinnells, and R H. Lush, Louisiana State College.

Five Years' Results in Pasture Fertilization—C. B. Bender, University of New Jersey.

Grain as a Supplement to Dairy Pastures—R. H. Lush, Louisiana State College.

Variations in Heart Rate and Body Temperature of Dairy Cows During the Twenty-Four Hour Cycle—I. W. Rupel, University of Wisconsin, and M. A. R. Kelley, Bureau of Dairy Industry, U. S. D. A.

Influence of Cottonseed Meal Rations on Reproduction—A. H. Kuhlman and Earl Weaver, Oklahoma A. and M. College.

Relation Between the Frequency of Service and the Fertility of Bulls—E. C. Elting and J. P. LaMaster, Clemson Agricultural College.

MINUTES OF THE EXECUTIVE COMMITTEE MEETING ON JUNE 27, 1933, URBANA, ILLINOIS

Those in attendance:

H. C. JACKSON, President.
R. B. STOLTZ, Vice-President.
A. C. DAHLBERG, Editor.
R. R. GRAVES, Secretary-Treasurer.
C. R. GEARHART, Chairman Extension Section.

J. O. BARKMAN, Chairman Manufacturing Section.
J. H. HILTON, Chairman Production Section.

The proposed amendments to the constitution which were submitted to the members for their approval last February failed of ratification because a sufficient number of members did not return their votes. C. L. Roadhouse and A. C. Borland, of the Committee on Constitution, submitted to the Executive Committee for its approval the desirability of some further changes in the constitution and the desirability of presenting the articles as amended to the members for their vote at the business meeting. The proposed changes and the submission of the amended articles to the members at the business meeting for vote, was approved by the Executive Committee.

O. F. Hunziker, Chairman of the Journal Management Committee submitted for approval the following recommendation relative to the publication of the proceedings of the annual meeting:

The committee recommends that the printing of the complete papers be kept in mind until such time as conditions return to normal but that in the meantime the publishing of abstracts be continued by the Program Committee, but that if advertising be solicited it be confined to local advertisers.

Recommendation approved.

The appointment of an auditing committee consisting of R. W. Bell, Alan Leighton and B. H. Webb, was approved.

The appointment of a Nominating Committee consisting of H. A. Ruehe, Chairman, W. V. Price, T. W. Gullickson, W. M. Neal, and H. F. Gregory, was approved.

A Resolutions Committee consisting of A. C. Borland, Chairman, Fordyce Ely, Earl Weaver, E. L. Anthony and A. R. Merrill, was also approved.

A motion was adopted that the Dairy Economics Section be abolished because of the fact that it is not functioning.

The committee voted to accept a joint invitation to hold the 1934 meeting at Cornell University and the Geneva Experiment Station.

The Executive Committee voted affirmatively on the following recommendation of the Journal Management Committee:

That articles be accepted only from authors who are either members of the Association or subscribers to the Journal, provided, however, that in case of joint authorship this ruling applies to one author only.

The Journal Management Committee was authorized to put the Journal on a 12 issue basis for 1934 and if needed to use up to $4.00 of the membership fee for the Journal.

A. C. Dahlberg was reappointed as Editor and R. R. Graves was reappointed as Secretary-Treasurer.

The reports of the Editor and Journal Management Committee and of the Secretary-Treasurer were received and approved.

MINUTES OF THE BUSINESS MEETING OF THE AMERICAN DAIRY SCIENCE ASSOCIATION AT URBANA, ILLINOIS, JUNE 28, 1933

H. C. JACKSON, *President, presiding*

A. C. Roadhouse, representing the Committee on Constitution, discussed the various changes in the By-laws that were proposed, and submitted them for approval. The proposed amendments were adopted unanimously. (The By-laws, as amended will be published in an early issue of the Journal).

The following report of the Nominating Committee was approved:

REPORT OF COMMITTEE ON NOMINATIONS

Your Committee on Nominations desire to submit the following report:

Candidates for Vice-President:

C. L. ROADHOUSE of California
H. W. GREGORY of Purdue

It was the opinion of the Committee that since members of the Board of Directors were not elected by the last "mail ballot" due to a technicality, they should recommend adopting the report of the Committee on Elections as submitted June, 1932. However, since Professor C. L. Roadhouse is being nominated for Vice-President, it is necessary to substitute another member in his place.

The Committee therefore recommends the following nominations:

For members of Board of Directors for one-year term:

EARL WEAVER
C. R. GEARHART

For two-year term:

H. B. ELLENBERGER
O. F. HUNZIKER

For three-year term:

L. A. ROGERS
H. A. RUEHE

Respectfully submitted,
W. M. NEAL
T. W. GULLICKSON
W. V. PRICE
H. W. GREGORY
H. A. RUEHE

A. C. Borland presented the report of the Resolutions Committee, which follows:

1. WHEREAS the members of the American Dairy Science Association have thoroughly enjoyed their visit at the University of Illinois and feel greatly indebted to those who are responsible for the many courtesies extended to the members, *be it resolved*

That the Association in convention assembled take this opportunity to express our appreciation to Dean Mumford for his gracious interest in the meetings and especially to thank him and Mrs. Mumford for the delightful reception at their home.

That the thanks of the members be particularly extended to Professor Ruehe and the members of his staff for their untiring efforts in making the necessary arrangements which have contributed so greatly to the success of the meeting. It is also the wish of the association to thank other members of the staff of the College of Agriculture who made the members feel so welcome wherever they went on the campus and who assisted with the tour.

That the association go on record as being particularly grateful to Miss Eileen Shannon and her staff of workers in the stenographic service of the Experiment Station for their efforts in preparing the abstract volume in such useful and complete form.

2. WHEREAS, the President of the Association, H. C. Jackson, the Vice-President, R. B. Stoltz, the Secretary, R. R. Graves, and the Editor of the Journal of Dairy Science, A. C. Dahlberg, have expended much time and effort in carrying on the work of the association during the year

Be it resolved: that the members of the association express to these officers their appreciation and thanks for their splendid service.

3. *Be it resolved:* that we, as members of the Dairy Science Association, as a body, extend to Professor Fraser our appreciation for his early vision which brought this association into being and wish for him many future years of good health and happiness and association with this organization.

4. *Be it resolved:* that in the untimely passing of one of its charter members, Dr. Clarence Henry Eckles, this organization has lost a most highly esteemed friend, counselor and adviser.

We express to his family our deepest grief and sorrow in our mutual loss.

5. Since it is an accepted fact that many of the cows in our dairy herds are "boarder cows" and that the reason why these cows are maintained is due to the limited testing program now in effect.

Be it resolved: that this association go on record as strongly recommending the mass testing of our dairy herds either by the use of the Dairy Herd Improvement Association, or the Breed Herd Tests and *be it further resolved* that this association recommends and strongly urges the Dairy Extension Institutional Staffs in each State to put on an aggressive program to promote the wider use of their breed herd tests for the purpose of developing greater breed efficiency.

6. WHEREAS, the Federal Government in its new Agricultural Relief Act is definitely committed to a program of curtailment in agricultural production,

Be it resolved: that this association lend its endorsement to the Federal program and proffer its assistance in the fulfilment thereof.

Be it further resolved: that the association heartily commend the administration in its efforts to improve the situation through the elimination of inferior cows.

Be it further resolved: that the association endorse the efforts the industry is exerting in establishing itself in a high plane of business ethics and to this end we proffer the whole hearted support of the association.

FORDYCE ELY
EARL WEAVER
A. R. MERRILL
E. L. ANTHONY
A. A. BORLAND

The report of the Extension Section was received.

The report of the Production Section was received.

The report of the Manufacturing Section was received.

The recommendation of the Journal Management Committee concerning authors of articles in the Journal being members or subscribers was presented and approved.

The report of a committee appointed to consider the basis on which certificates should be granted for non-collegiate work in dairying, was approved. Report follows:

Your committee appointed for the purpose of investigating the basis on which certificates should be granted by colleges for non-collegiate work in Dairying begs to submit the following report:

Questionnaires were mailed to the various dairy departments. Twenty-seven replies were received; of these ten are offering non-collegiate dairy courses for the training of creamery operators and six of these offer certificates upon the completion of the work. Schools offering the shorter courses issue the certificates after the students have obtained a certain amount of practical experience in commericial plants.

Three schools, Pennsylvania, California and Massachusetts, offer two-year courses; Iowa offers a twelve months' course, of which six months' work is taken during one year, followed by five months of practical experience, upon completion of which the students enter for the remaining six months of work at the school. The balance of the schools from which reports were received offer courses extending from six weeks to five months.

Although eleven of the twenty-seven replies were favorable toward having some uniform standard for the issuing of certificates, only four of the schools offering non-collegiate courses were in favor thereof, since it was the opinion of several that each state has its own particular problems to solve and that the non-collegiate courses are offered to meet such more or less local needs.

Judging from the information obtained it is evident that we are not, so far, ready to recommend a uniform basis on which certificates for non-collegiate work should be granted, and we wish to recommend that the Committee be discontinued. It is indicated, however, from a number of replies received that the dairy instructors are interested in strengthening the non-collegiate dairy courses, since most of our plant operators receive their training through such courses. The dairy problems are gradually becoming more complex, and it is the duty of the State Dairy Departments to give work that will fit the young men for the future dairy problems.

Signed:

A. A. BORLAND
J. M. SHERMAN
W. B. COMBS
M. MORTENSEN, *Chairman*

Adjournment. June, 1933.

American Dairy Science Association Announcements

NEWLY ELECTED OFFICERS

The following officers have been elected for the ensuing year by mail ballot:

Vice-President: C. L. ROADHOUSE, University of California

Members of the Board of Directors:

For 1 year term:

EARL WEAVER, Oklahoma State College

For 2 year term:

O. F. HUNZIKER, Blue Valley Creamery Company

For 3 year term:

L. A. ROGERS, Bureau of Dairy Industry

According to a provision of the newly adopted by-laws R. B. Stoltz, of the Ohio State University, Vice-President last year, automatically succeeded to the Presidency.

The election of the new officers became effective October 1, 1933.

MONTHLY JOURNAL PUBLICATION

The officers of your association are pleased to announce that the JOURNAL OF DAIRY SCIENCE will be published monthly beginning January, 1934. Your executive committee and the committee on journal management have had this matter under consideration for several years. They realize the advantages of monthly publications, and giving to the members and subscribers an enlarged JOURNAL.

Authorship is limited to membership so that we will secure a more prompt publication of the material submitted to the JOURNAL. It is expected that the JOURNAL next year will contain about forty per cent more material than that published per volume prior to 1932. We are not increasing either the membership dues or subscription rates, but propose that this increased number of journals be taken care of by a larger membership. We trust that each member and subscriber will show his appreciation of our enlarging the JOURNAL by assisting in getting new members and new subscribers.

Your President would appreciate receiving suggestions and criticisms that we might improve the association and the JOURNAL so that they may be of greater service to the dairy industry.

R. B. STOLTZ

STUDENTS NATIONAL CONTEST IN JUDGING DAIRY PRODUCTS—HELD IN CHICAGO, ILLINOIS, SEPTEMBER 18, 1933

Teams from seventeen state agricultural colleges participated in this annual contest sponsored by the American Dairy Science Association and the Dairy and Ice Cream Machinery and Supplies Association, Inc.

A $600.00 Dairy Industrial Fellowship is awarded to each of the six highest individuals in all products. Other awards are: Five gold, five silver and five bronze medals, and five silver cups. These are all financed by the Dairy and Ice Cream Machinery and Supplies Association, Inc. They also invited all teams and their coaches as their guests at the annual banquet of the International Association of Ice Cream Manufacturers.

The International Association of Milk Dealers awarded one gold medal to the individual ranking first in judging milk; and the International Association of Ice Cream Manufacturers presented one gold medal to the individual scoring highest in judging ice cream.

Following is a list of those who won high standings in the contest:

ALL PRODUCTS

Individuals

1. Willard J. Corbett, University of Illinois—Fellowship and Gold Medal
2. Pius Hostetler, Kansas State College—Fellowship and Silver Medal
3. Harley Chilson, Kansas State College—Fellowship and Bronze Medal
4. R. L. Carithers, Mississippi State College—Fellowship
5. Cleve M. Sorenson, University of Minnesota—Fellowship
6. Delmar Spicer, South Dakota State College—Fellowship

Teams

1. Ohio State University—Sweepstakes Silver Trophy
2. Kansas State College
3. South Dakota State College

BUTTER

Individuals

1. Delmar Spicer, South Dakota State College—Gold Medal
2. Joe L. Norman, Iowa State College—Silver Medal
3. Richard Buehler, Ohio State University—Bronze Medal

Teams

1. South Dakota State College—Silver Trophy
2. Ohio State University
3. Mississippi State College

CHEESE

Individuals

1. William Ralston, University of Nebraska—Gold Medal
2. Walter Uphoff, University of Wisconsin—Silver Medal
3. Glenn H. Hagberg, University of Wisconsin—Bronze Medal

Teams

1. University of Wisconsin—Silver Trophy
2. Mississippi State College
3. Michigan State College

MILK

Individuals

1. Willard J. Corbett, University of Illinois—Two Gold Medals
2. Cleve M. Sorensen, University of Minnesota—Silver Medal
3. Vergil N. Simmons, University of Illinois—Bronze Medal

Teams

1. University of Illinois—Silver Trophy
2. Kansas State College
3. Ohio State University

ICE CREAM

Individuals

1. Clare E. Monroe, Michigan State College—Two Gold Medals
2. Harold Montgomery, University of Arkansas—Silver Medal
3. Enoch B. Norum, University of Minnesota—Bronze Medal

Teams

1. Massachusetts State College—Silver Trophy
2. Michigan State College
3. University of Arkansas

LIST OF THE SEVENTEEN TEAMS ENTERED IN THE CONTEST

University of Arkansas
Connecticut State College
Cornell University
University of Illinois
Iowa State College
Kansas State College
Massachusetts State College
Michigan State College
University of Minnesota
Mississippi State College
University of Nebraska
Ohio State University
Oklahoma A. & M. College
Purdue University
South Dakota State College
West Virginia University
University of Wisconsin

R. B. Stoltz

NEWS ITEM

Members of the Bureau of Dairy Industry, U. S. Department of Agriculture, with their families were present the evening of August 14 at an informal gathering in the nearly completed nutrition laboratory at the Beltsville, Md., Station, where a tablet was unveiled in the entrance hall on which the following was inscribed:

> "In recognition of the services of Earl E. Parks in the design and construction of buildings at this and other stations, this tablet is erected by his associates in the Bureau of Dairy Industry, August 1933."

Mr. Parks has been with the U. S. Department of Agriculture since March 1, 1907. Many of the publications of the Bureau of Dairy Industry, and the former Dairy Division, contain information which was prepared by Mr. Parks.

W. E. Wintermeyer was assigned on August 8 to dairy extension work in the South. In this work he is employed cooperatively by the Bureau of Dairy Industry and the Office of Cooperative Extension Work. His territory includes the following 12 states: Alabama, Arkansas, Florida, Georgia, Louisiana, Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee, Texas, and Virginia. For many years Mr. Wintermeyer has been in charge of the proved-sire work in the Division of Dairy Herd-Improvement Investigations, Bureau of Dairy Industry. During this time he has put out several important publications connected with that work. His work in the Bureau and his previous training have given him excellent preparation for his new position. He has traveled extensively in the Southern States, is well acquainted with the extension men and with many of the leading dairy farmers in the South, and understands well the extension problems of that district.

INDEX TO VOLUME XVI

(ACIDITY) An improved method for preparing the serum of butter for pH determination 249
Acidity produced in milk by the citric acid fermenting streptococci, The source of the volatile 157
Acid milk in bovine mastitis 111
Acidosis in dairy cattle, Dietary 413
Alcohol as an error in the Gerber test, Amyl 557
American Dairy Science Association, Proceedings of the 28th annual meeting of the 587
American Dairy Science Association, The formation of the 582

BACTERIA in dairy products, The Escherichia-aerobacter group of 481
Bacteria in milk, with special reference to standards, The significance of colon 165
Bacterial and cell content of milk, The effect of various methods for drying up cows on the 79
Bacterial count and hydrogen ion concentration for the detection of mastitis, The leucocyte content of milk as correlated with 59
Bacterial flora of the ice cream mix, The effect of pasteurizing on the 435
Bacteriological analysis of ice cream, The 277
(Bacteriology) A modification of the method for the direct microscopic examination of ice cream and other dairy products 311
(Bacteriology) Influence of different starters on the quality of cheddar cheese 121
(Bacteriology) Microbiology of frozen foods 315
(Bacteriology) Studies on the butter culture organisms in butter 375
(Bacteriology) The influence of media upon the yeast and mold count of butter 141
(Bacteriology) Thermophilic streptococci as starters for Swiss cheese 387
(Bacteriology) The source of the volatile acidity produced in milk by the citric acid fermenting streptococci 157
Beet pulp for milk production, Wet versus dry 363
BENDIXEN, H. A. (See Hansen, H. C.) 121
BETHKE, R. M. (See Krauss, W. E.)
Bitter substance in "Bitterweed" milk, The determination of 401
Blood glucose on milk sugar, The effect of increased 347
Bull index problem in the light of modern genetics, The 501
BURKEY, L. A. (See Frazier, W. C.) 387
Butter culture organisms in butter, Studies on the 375
Butter for pH determination, An improved method for preparing the serum of 249
Buttermilk and their effect upon the accuracy of the various fat tests, The phospholipids in 460
Butter produced by Guernsey and Ayrshire cows, The vitamin A activity 153
Butter, The comparative vitamin A content of nut-margarines and 559
Butter, The influence of media upon the yeast and mold count of 141
Butter, The microbiological analysis of 289
Butter through winter feeding conditions, Maintaining the vitamin A value of 355

CALCIUM and phosphorus of cheese made under controlled conditions 253
CANNON, C. Y. Seasonal effect on yield of dairy cows 11
CANNON, C. Y. (See Wilson, John L.) 427
Cattle, A study of the phosphorus requirement of dairy 203
Cattle, Dietary acidosis in dairy 413
CAULFIELD, W. J. (See McCammon, R. B.) 253
CAULFIELD, W. J., and MARTIN, W. H.

The use of vegetable stabilizers in ice cream 265
Chemical analysis of butter, The 300
CHERRINGTON, V. A., HANSEN, H. C., and HALVERSEN, W. V. The leucocyte content of milk as correlated with bacterial count and hydrogen ion concentration for the detection of mastitis 59
Cheese, Factors governing the manufacture of sweet-curd cottage 467
Cheese, Influence of different starters on the quality of cheddar 121
Cheese made under controlled conditions, Calcium and phosphorus of 253
Cheese, Thermophilic streptococci as starters for Swiss 387
Churning, Substances adsorbed on the fat globules in cream and their relation to 41
Citric acid fermenting streptococci, The source of the volatile acidity produced in milk by the 157
COLE, L. J., and JOHANSSON, IVAR. The yield and composition of milk from Aberdeen-Angus cows 565
Colon bacteria in milk, with special reference to standards, The significance of 165
Condensed skimmilk, The use of corn sugar in the manufacture of 17
CONVERSE, H. T. (See Meigs, Edward B.) 317
Corn sugar in the manufacture of sweetened condensed skimmilk, The use of 17
Cottage cheese, Factors governing the manufacture of sweet-curd 467
Cows and the effect of different methods upon milk production, Drying up 69
Cows fed rations of varying fat content, The apparent and true sugar of the blood of lactating 33
Cows on fertilized pasture, The proper supplementary ration for milking 407
Cows on the bacterial and cell content of milk, The effect of various methods for drying up 79
Cows, Seasonal effect on yield of dairy 11
Cows, Some effects of different kinds of hay in the ration on the performance of dairy 317
Cows, The effects of some fly sprays on the hides and on the body temperatures of dairy 427
Cows, The yield and composition of milk from Aberdeen-Angus 565
Cream and their relation to churning, Substances adsorbed on the fat globules in 41
Cream, Studies on whipping 329
Cream, Viscosity studies of fluid 1
CROUCH, RHODA. (See Wallace, G. I.) 315
Crystallization of lactose in ice cream, Some factors influencing the 177
Curd for poultry feeding, The preservation of skimmilk 495
Curd milk, Laboratory studies on the chemistry of soft 225

DAHLE, C. D., and FOLKERS, E. C. Factors contributing to an off-flavor in ice cream 529
Dairy products, A modification of the method for the direct microscopic examination of ice cream and other 311
Dairy products, Methods of analyzing 277
Dairy products, The Escherichia-aerobacter group of bacteria in 481
DAVIS, R. N. The preservation of skimmilk curd for poultry feeding 495
DEYSHER, EDGAR F. (See Holm, George E.) 445
DUBOIS, CHARLES M., and MARTIN, W. H. The effect of pasteurizing on the bacterial flora of the ice cream mix 435
DUNCAN, C. W. (See Huffman, C. F.) 203

ECKLES, CLARENCE HENRY 273
ECKLES, C. H. (See Wayne, Ralph) 69
ELLENBERGER, H. B. (See Guthrie, E. S.) 300

FABIAN, F. W. (See Fay, A. C.) 277
Fat content, The apparent and true sugar of the blood of lactating cows fed rations of varying 33
Fat globules in cream and their relation to churning, Substances adsorbed on the 41

Fat tests, The phospholipids in buttermilk and their effect upon the accuracy of various 460
FAY, A. C. A modification of the method for the direct microscopic examination of ice cream and other dairy products 311
FAY, A. C., HAMMER, B. W., and FABIAN, F. W. The bacteriological analysis of ice cream 277
Feeding a cod-liver oil concentrate to cows on the vitamin D content of milk, The effect of 549
FEHLMAN, HAZEL A. (See Poe, Charles E.) 559
(Flavor) Factors contributing to an off-flavor in ice cream 529
(Flavor) The determination of the bitter substance in "Bitterweed" milk 401
Fly sprays on the hides and on the body temperatures of dairy cows, The effects of some 427
FOLEY, RICHARD C. The proper supplementary ration for milking cows on fertilized pasture 407
FOLKERS, E. C. (See Dahle, C. D.) 529
Foods, Microbiology of frozen 315
FRAZIER, W. C., BURKEY, L. A., MATHESON, K. J., and WATSON, P. D. Thermophilic streptococci as starters for Swiss cheese 387
FRASER, WILBUR J. The formation of the American Dairy Science Association 582
Frozen foods, Microbiology of 315

GENETICS, The bull index problem in the light of modern 501
Gerber test, Amyl alcohol as an error in the 557
GUTHRIE, E. S., MANHART, V. C., NELSON, D. H., and ELLENBERGER, H. B. The chemical analysis of butter 300

HALVERSEN, W. V. (See Hansen, H. C.) 59
HAMMER, B. W. (See Fay, A. C.) 277
HAMMER, B. W. (See Michaelian, M. B.) 157
HAMMER, B. W. (See Nelson, J. A.) 375
HAMMER, B. W. (See Parfitt, E. H.) 289
HANSEN, H. C., BENDIXEN, H. A., and THEOPHILUS, D. R. Influence of different starters on the quality of cheddar cheese 121
HANSEN, H. C. (See Cherrington, V. A.) 59
HAUGE, S. M. (See Hilton, J. H.) 355
HAUGE, S. M. (See Wilbur, J. W.) 153
Hay in the ration on the performance of dairy cows, some effects of different kinds of 317
HENDERSON, H. O., and TEAGUE, C. E. Wet versus dry beet pulp for milk production 363
HERRINGTON, B. L. Amyl alcohol as an error in the Gerber test 557
HILTON, J. H., HAUGE, S. M., and WILBUR, J. W. Maintaining the vitamin A value of butter through winter feeding conditions 355
HILTON, J. W. (See Wilbur, J. W.) 153
HODGSON, R. E. (See Whitnah, C. H.) 347
HOLDAWAY, CHARLES W., and PRATT, AVERY D. Progress report of pasture fertilization at the Virginia Agricultural Experiment Station 95
HOLM, GEORGE E., WRIGHT, PHILIP R., and DEYSHER, EDGAR F. The phospholipids in milk: I. Their distribution among some milk products 445
Homogenized cream, A note on the surface tension of 369
HOOD, E. G. (See Parfitt, E. H.) 289
HUFFMAN, C. F., ROBINSON, C. S., DUNCAN, C. W., LAMB, L. W., and MASON, M. F. A study of the phosphorus requirement of dairy cattle 203
Hydrogen ion concentration for the detection of mastitis, The leucocyte content of milk as correlated with bacterial count and 59
Hydrogen ion concentration of butter 249

ICE cream and other dairy products, A modification of the method for the direct microscopic examination of 311
Ice cream, Factors contributing to an off-flavor in 529

Ice cream mix, The effect of pasteurizing on the bacterial flora of the.... 435
Ice cream, Some factors influencing the crystallization of lactose in 177
Ice cream, The bacteriological analysis of 277
Ice cream, The use of vegetable stabilizers in 265

JOHANSSON, IVAR, and KNUDSEN, M. H. Lactation in a barren heifer 523
JOHANSSON, IVAR. (See Cole, L. J.).. 565
JOHNSON, A. H. (See Weisberg, S. M.) 225
JONES, F. S., and LITTLE, RALPH B. Acid milk in bovine mastitis 111
JONES, F. S., and LITTLE, RALPH B. Proteins of the whey fraction in milk from normal and abnormal udders 101

KNUDSEN, M. H. (See Johansson, IVAR.) 523
KRAMER, M. M. (See McCammon, R. B.) 253
KRAUSS, W. E., BETHKE, R. M., and WILDER, WILLARD. The effect of feeding a cod-liver oil concentrate to cows on the vitamin D content of milk 547

LACTATION in a barren heifer 523
Lactose in ice cream, Some factors influencing the crystallization of 177
LAMB, L. W. (See Huffman, C. F.)..... 203
Leucocyte content of milk as correlated with bacterial count and hydrogen ion concentration for the detection of mastitis, The 41
(Leucocyte) The effect of various methods for drying up cows on the bacterial and cell content of milk..... 79
LITTLE, RALPH B. (See Jones, F. S.) 101
LITTLE, RALPH B. (See Jones, F. S.) 111
LUSH, JAY L. The bull index problem in the light of modern genetics.. 501
LUSH, R. H. Seasonal composition of pasture grasses 149

MACY, H. (See Parfitt, E. H.) 289
MACY, H. (See Wayne, Ralph.) 79
MANHART, V. C. (See Guthrie, E. S.) 300
MARTIN, W. H. (See Caulfield, W. J.) 265
MARTIN, W. H. (See Dubois, Charles M.) 435
MASON, M. F. (See Huffman, C. F.) 203
Mastitis, Acid milk in bovine 111
(Mastitis) Proteins of the whey fraction in milk from normal and abnormal udders 101
Mastitis, The leucocyte content of milk as correlated with bacterial count and hydrogen ion concentration for the detection of 59
MATHESON, K. J. (See Frazier, W. C.) 387
MCCAMMON, R. B., CAULFIELD, W. J., and KRAMER, M. M. Calcium and phosphorus of cheese made under controlled conditions 253
MCCOLLUM, E. V. (See Weisberg, S. M.) 225
Media upon the yeast and mold count of butter, The influence of 141
MEIGS, EDWARD B., and CONVERSE, H. T. Some effects of different kinds of hay in the ration on the performance of dairy cows 317
Methods of analyzing dairy products.. 277
MICHAELIAN, M. B., and HAMMER, B. W. The source of the volatile acidity produced in milk by the citric acid fermenting streptococci 157
Microscopic examination of ice cream and other dairy products, A modification of the method for the direct.. 311
Milk as correlated with bacterial count and hydrogen ion concentration for the detection of mastitis, The leucocyte content of 59
Milk by the citric acid fermenting streptococci, The source of the volatile acidity produced in 157
Milk from Aberdeen-Angus cows, The yield and composition of 565
Milk from normal and abnormal udders, Proteins of the whey fraction in 101
Milk in bovine mastitis, Acid 111
Milk, Laboratory studies on the chemistry of soft-curd 225
(Milk) Lactation in a barren heifer..... 523

Milk production, Drying up cows and the effect of different methods upon 69
Milk production, Wet versus dry beet pulp for 363
Milk secretion in the albino rat, Experimental imitation of 129
Milk, The determination of the bitter substance in "Bitterweed" 401
Milk, The effect of various methods for drying up cows on the bacterial and cell content of 79
Milk, The phospholipids in 445
Mold count of butter, The influence of media upon the yeast and 141
Monroe, C. F. (See Perkins, A. E.) 413
Mook, D. E. (See Nair, J. H.) 1

Nair, J. H., and Mook, D. E. Viscosity studies of fluid cream 1
Nelson, D. H. (See Guthrie, E. S.) 300
Nelson, J. A., and Hammer, B. W. Studies on the butter culture organisms in butter 375

Palmer, L. S., and Wiese, Hilda F. Substances adsorbed on the fat globules in cream and their relation to churning 41
Parfitt, E. H., Hood, E. G., Hammer, B. W., and Macy, H. The microbiological analysis of butter 289
Parfitt, E. H. The influence of media upon the yeast and mold count of butter 141
Pasteurizing on the bacterial flora of the ice cream mix, The effect of 435
Pasture fertilization at the Virginia Agricultural Experiment Station, Progress report of 95
Pasture grasses, Seasonal composition of 149
Pearson, A. M. (See Wilson, John L.) 427
Perkins, E. E., and Monroe, C. F. Dietary acidosis in dairy cattle 413
Peterson, W. E. (See Wayne, Ralph) 69
Phospholipids in milk, The 445
Phosphorus of cheese made under controlled conditions, Calcium and 253
Phosphorus requirement of dairy cattle, A study of the 203
Poe, Charles E., and Fehlman, Hazel A. The comparative vitamin A content of nut-margarines and butter 559
Pratt, Avery D. (See Holdaway, Chas. W.) 95
Proceedings of the 28th annual meeting of the American Dairy Science Association 587
Proteins of the whey fraction in milk from normal and abnormal udders 101

Ramsey, R. J., Tracy, P. H., and Ruehe, H. A. The use of corn sugar in the manufacture of sweetened condensed skimmilk 17
Rations of varying fat content, The apparent and true sugar of the blood of lactating cows fed 33
Riddell, W. H. (See Whitnah, C. H.) 347
Robinson, C. S. (See Huffman, C. S. (See Huffman, C. F.) 203
Ruehe, H. A. (See Ramsey, R. J.) 17

Schultze, A. B., and Turner, C. W. Experimental imitation of milk secretion in the albino rat 129
Seasonal composition of pasture grasses 149
Seasonal effect on yield of dairy cows 11
Secretion in the albino rat, Experimental imitation of milk 129
Sherman, James W., and Wing, Helen Upton. The significance of colon bacteria in milk, with special reference to standards 165
Skimmilk curd for poultry feeding, The preservation of 495
Skimmilk, The use of corn sugar in the manufacture of sweetened condensed 17
Sommer, H. H. (See Templeton, Hugh L.) 329
Stabilizers in ice cream, The use of 265
Starters on the quality of cheddar cheese, Influence of different 121
Sugar in the manufacture of sweetened condensed skimmilk, The use of corn 17
Sugar of the blood of lactating cows fed rations of varying fat content,

The apparent and true 33
Surface tension of homogenized cream, A note on the 369
Sugar, The effect of increased blood glucose on milk 347

TEAGUE, C. E. (See Henderson, H. O.) 363
TEMPLETON, HUGH L., and SOMMER, H. H. Studies on whipping cream .. 329
THEOPHILUS, D. R. (See Hansen, H. C.) 121
Thermophilic streptococci as starters for Swiss cheese 387
THURSTON, L. M., and GOULD, IRA, JR. Factors governing the manufacture of sweet-curd cottage cheese 467
TRACY, P. H. (See Ramsey, R. J.) 17
TURK, KENNETH, L., and WORK, SAMUEL H. The apparent and true sugar of the blood of lactating cows fed rations of varying fat content .. 33

VISCOSITY studies of fluid cream 1
Vitamin A activity of butter produced by Guernsey and Ayrshire cows, The 153
Vitamin A content of nut-margarines and butter, The comparative 559
Vitamin A value of butter through winter feeding conditions, Maintaining the 355
Vitamin D content of milk, The effect of feeding a cod-liver oil concentrate to cows on the 549

WALLACE, G. I., and CROUCH, RHODA. Microbiology of frozen foods 315
WATSON, P. D. (See Frazier, W. C.) 387
WAYNE, RALPH, and MACY, H. The effect of various methods for drying up cows on the bacterial and cell-content of milk 79
WAYNE, RALPH, ECKLES, C. H., and PETERSON, W. E. Drying up cows and the effect of different methods upon milk production 69
WEATHERS, NORABELLE D. The determination of the bitter substance in "Bitterweed" milk 401
WEBB, BYRON H. A note on the surface tension of homogenized cream .. 369
WECKEL, K. G. An improved method for preparing the serum of butter for pH determination 249
WEISBERG, S. M., JOHNSON, A. H., and MCCOLLUM, E. V. Laboratory studies on the chemistry of soft-curd milk 225
Whey fraction in milk from normal and abnormal udders, Proteins of 101
Whipping cream, Studies on 329
WHITNAH, C. H., RIDDELL, W. H., and HODGSON, R. E. The effect of increased blood glucose on milk sugar 347
WIESE, HILDA F. (See Palmer, L. S.) 41
WILBUR, J. W., HILTON, J. H., and HAGUE, S. M. The vitamin A activity of butter produced by Guernsey and Ayrshire cows 153
WILBUR, J. W. (See Hilton, J. H.) 355
WILDER, WILLARD. (See Krauss, W. E.) 549
WILSON, JOHN L., PEARSON, A. M., and CANNÓ, C. Y. The effects of some fly sprays on the hides and on the body temperatures of dairy cows 427
WING, HELEN UPTON. (See Sherman, James W.) 165
WORK, SAMUEL H. (See Turk, Kenneth L.) 33
WRIGHT, PKILIP R. (See Holm, George E.) 445

YALE, M. W. The Escherichia-aerobacter group of bacteria in dairy products 481
Yeast and mold count of butter, The influence of media upon the 141

JOURNAL
OF
DAIRY SCIENCE

VOLUME XVI

JANUARY, 1933, TO NOVEMBER, 1933

1933
THE SCIENCE PRESS PRINTING COMPANY
LANCASTER, PENNSYLVANIA

EDITORIAL BOARD

A. C. DAHLBERG, *Editor*
Geneva, N. Y.

Associate Editors

L. S. PALMER
St. Paul, Minn.

C. W. LARSON
Buffalo, N. Y.

H. A. RUEHE
Urbana, Ill.

E. G. HASTINGS
Madison, Wis.

E. B. MEIGS
Beltsville, Md.

PAUL F. SHARP
Ithaca, N. Y.

O. F. HUNZIKER
Chicago, Ill.

L. A. ROGERS
Washington, D. C.

C. E. GRAY
San Francisco, Cal..

Committee on Journal Management

O. F. HUNZIKER, Chairman
Chicago, Ill.

R. R. GRAVES
Washington, D. C.

A. A. BORLAND
State College, Pa.

Correspondence regarding business policies of the Journal should be addressed to the Editor. The use of material published in the Journal is encouraged and a liberal policy will be followed concerning reproduction of articles with proper notation as to source.

Subscriptions and Advertising should be mailed direct to the Science Press Printing Company, Lime and Green Streets, Lancaster, Pennsylvania.

CONTENTS

JANUARY. NO. 1

Viscosity Studies of Fluid Cream. J. H. Nair and D. E. Mook 1
Seasonal Effect on Yield of Dairy Cows. C. Y. Cannon 11
The Use of Corn Sugar in the Manufacture of Sweetened Condensed Skimmilk. R. J. Ramsey, P. H. Tracy and H. A. Ruehe 17
The Apparent and True Sugar of the Blood of Lactating Cows Fed Rations of Varying Fat Content. Kenneth L. Turk and Samuel H. Work 33
Substances Adsorbed on the Fat Globules in Cream and Their Relation in Churning. II. The Isolation and Identification of Adsorbed Substances. L. S. Palmer and Hilda F. Wiese 41
The Leucocyte Content of Milk as Correlated with Bacterial Count and Hydrogen Ion Concentration for the Detection of Mastitis. V. A. Cherrington, H. C. Hansen, and W. V. Halversen 59
Drying Up Cows and the Effect of Different Methods Upon Milk Production. Ralph Wayne, C. H. Eckles and W. E. Peterson 69
The Effect of Various Methods for Drying Up Cows on the Bacterial and Cell Content of Milk. Ralph Wayne and H. Macy 79

MARCH. NO. 2

Progress Report of Pasture Fertilization at the Virginia Agricultural Experiment Station. Charles W. Holdaway and Avery D. Pratt 95
Proteins of the Whey Fraction in Milk from Normal and Abnormal Udders. F. S. Jones and Ralph B. Little 101
Acid Milk in Bovine Mastitis. B. S. Jones and Ralph B. Little 111
Influence of Different Starters on the Quality of Cheddar Cheese. H. C. Hansen, H. O. Bendixen and D. R. Theophilus 121
Experimental Initiation of Milk Secretion in the Albino Rat. A. B. Schultze and C. W. Turner 129
The Influence of Media Upon the Yeast and Mold Count of Butter. E. H. Parfitt 141
Seasonal Composition of Pasture Grasses. R. H. Lush 149
The Vitamin A Activity of Butter Produced by Guernsey and Ayshire Cows. J. W. Wilbur, J. H. Hilton and S. M. Hauge 153
The Source of the Volatile Acidity Produced in Milk by the Citric and Acid Fermenting Streptococci. M. B. Michaelian and B. W. Hammer 157
The Significance of Colon Bacteria in Milk, with Special Reference to Standards. James M. Sherman and Helen Upton Wing 165
Association Announcements and News 175

MAY. NO. 3

Some Factors Influencing the Crystallization of Lactose in Ice Cream. Randall Whitaker 177
A Study of the Phosphorus Requirement of Dairy Cattle. C. F. Huffman, C. S. Robinson, C. W. Duncan, L. W. Lamb and M. F. Mason 203
Laboratory Studies on the Chemistry of Soft Curd Milk. S. M. Weisberg, A. H. Johnson and E. V. McCollum 225
An Improved Method for Preparing the Serum of Butter for pH Determination. K. G. Weckel 249

Calcium and Phosphorus of Cheese Made Under Controlled Conditions. R. B. McCammon, W. J. Caulfield and M. M. Kramer 253
The Use of Vegetable Stabilizers in Ice Cream. W. J. Caulfield and W. H. Martin 265
Clarence Henry Eckles 273
Committee Reports: Methods of Analyzing Dairy Products—The Bacteriological Analysis of Ice Cream; The Microbiological Analysis of Butter; The Chemical Analysis of Butter 277
Association Announcements and News 307

JULY. NO. 4

A Modification of the Method for the Direct Microscopic Examination of Ice Cream and Other Dairy Products. A. C. Fay 311
Microbiology of Frozen Foods. G. I. Wallace and Rhoda Crouch 315
Some Effects of Different Kinds of Hay in the Ration on the Performance of Dairy Cows. Edward B. Meigs and H. T. Converse 317
Studies on Whipping Cream. Hugh L. Templeton and H. H. Sommer 329
The Effect of Increased Blood Glucose on Milk Sugar. C. H. Whitnah, W. H. Riddell and R. E. Hodgson 347
Maintaining the Vitamin A Value of Butter Through Winter Feeding Conditions. J. H. Hilton, S. M. Hauge and J. W. Wilbur 355
Wet Versus Dry Beet Pulp for Milk Production. H. O. Henderson and C. E. Teague 363
A Note on the Surface Tension of Homogenized Cream. Byron H. Webb 369
Studies on the Butter Culture Organisms in Butter. J. A. Nelson and B. W. Hammer 375
Thermophilic Streptococci as Starters for Swiss Cheese. W. C. Frazier, L. A. Burkey, K. J. Matheson and P. D. Watson 387
The Determination of the Bitter Substance in "Bitterweed" Milk. Norabelle D. Weathers 401
Association Announcements and News 405

SEPTEMBER. NO. 5

The Proper Supplementary Ration for Milking Cows on Fertilized Pasture. Richard C. Foley 407
Dietary Acidosis in Dairy Cattle. A. E. Perkins and C. F. Monroe 413
The Effects of Some Fly Sprays on the Hides and on the Body Temperatures of Dairy Cows. John L. Wilson, A. M. Pearson and C. Y. Cannon 427
The Effect of Pasteurizing on the Bacterial Flora of the Ice Cream Mix. Charles M. Dubois and W. H. Martin 435
The Phospholipids in Milk:
I. *Their Distribution Among Some Milk Products.* George E. Holm, Philip R. Wright and Edgar F. Deysher 445
II. *The Phospholipids in Skimmilks and Their Effect Upon the Accuracy of the Various Fat Tests.* Philip A. Wright and George E. Holm 455
III. *The Phospholipids in Buttermilk and Their Effect Upon the Accuracy of Various Fat Tests.* Philip A. Wright, Edgar F. Deysher and George E. Holm 460
Factors Governing the Manufacture of Sweet-Curd Cottage Cheese. L. M. Thurston and Ira Gould, Jr. 467
The Escherichia-Aerobacter Group of Bacteria in Dairy Products. M. W. Yale 481
The Preservation of Skimmilk Curd for Poultry Feeding. R. N. Davis 495

NOVEMBER. NO. 6

The Bull Index Problem in the Light of Modern Genetics. JAY L. LUSH 501
Lactation in a Barren Heifer. IVAR JOHANSSON AND M. H. KNUDSEN 523
Factors Contributing to an Off-Flavor in Ice Cream. C. D. DAHLE AND E. C. FOLKERS 529
The Effect of Feeding a Cod-Liver Oil Concentrate to Cows on the Vitamin D Content of Milk. W. E. KRAUSS, R. M. BETHKE AND WILLARD WILDER 549
Amyl Alcohol as a Source of Error in the Gerber Test. B. L. HERRINGTON 557
The Comparative Vitamin A Content of Nut-Margarines and Butter. CHARLES F. POE AND HAZEL A. FEHLMANN 559
The Yield and Composition of Milk from Aberdeen-Angus Cows. L. J. COLE AND IVAR JOHANSSON 565
The Formation of the American Dairy Science Association. WILBUR J. FRASER 583
Proceedings of the 28th Annual Meeting of the American Dairy Science Association 587
Membership of the American Dairy Science Association 597
Index to Volume XVI 601

Back Numbers

JOURNAL OF DAIRY SCIENCE

Complete sets of volumes 2 to 9 inclusive and 12, 13 and 14 are available, also many individual numbers and volumes.

Professors of Dairy Industry

Send for FREE working samples of Hansen's Butter Color, Cheese Rennet, Cheese Color, and Lactic Cultures for classroom work.

We will gladly furnish envelopes containing educational literature for all your students, without charge.

CHR. HANSEN'S LABORATORY, Inc.
MILWAUKEE, WIS.
Little Falls, N. Y. Toronto, Ont.

THE JOURNAL OF NUTRITION

EDITORIAL BOARD

Thorne M. Carpenter; Edward P. Cathcart; Eugene F. DuBois; Herbert M. Evans; Ernest B. Forbes; Elmer V. McCollum; Lafayette B. Mendel; Harold H. Mitchell; Mary S. Rose; Henry C. Sherman; Harry Steenbock.

John R. Murlin, Managing Editor, Rochester, N. Y.

THE MATERIAL published in this Journal consists only of articles describing original researches and occasional reviews of the literature on topics with which the Journal is concerned.

PRICE: Current Volume: $4.50, United States and Canada; $5.00, other countries, including United States possessions. Back Volumes, Vols. 1, 2, 3, 4, and 5, $27.50, United States and Canada; $30.00, other countries, including United States possessions.

Order from the Publisher

CHARLES C THOMAS

220 East Monroe Street **Springfield, Illinois**

Your advertisement is being read in every State and in 25 Foreign Countries

JOURNAL OF DAIRY SCIENCE

OFFICIAL ORGAN OF
AMERICAN DAIRY SCIENCE ASSOCIATION

A. C. DAHLBERG, Editor
Geneva, N. Y.

Associate Editors

L. S. PALMER, *St. Paul, Minn.*
E. G. HASTINGS, Madison, Wis.
O. F. HUNZIKER, Chicago, Ill.
C. W. LARSON, Buffalo, N. Y.
E. B. MEIGS, Beltsville, Md.
L. A. ROGERS, Washington, D. C.
H. A. RUEHE, Urbana, Ill.
PAUL F. SHARP, Ithaca, N. Y.
C. E. GRAY, San Francisco, Cal.

Committee on Journal Management

O. F. HUNZIKER, Chairman
Chicago, Ill.

R. R. GRAVES, Washington, D. C.
A. A. BORLAND, State College, Pa.

The Journal of Dairy Science is issued bi-monthly, appearing in January, March, May, July, September, and November. Subscription is by the volume and one volume is issued per year.

Manuscripts should be typewritten and carefully revised before submission to A. C. Dahlberg, New York Agricultural Experiment Station, Geneva, New York. Fifty reprints will be furnished gratis to authors. Cost of additional reprints and reprint order blank will be submitted with proof.

Subscriptions. Price; $5.00 per volume in United States, Canada and countries within the postal union; $5.50 in countries outside the postal union. Prices are net, postpaid. New subscriptions and renewals are entered to begin with the first issue of the current volume unless otherwise stated. Renewals should be made promptly to avoid a break in the series.

Subscriptions and Advertising should be mailed direct to the Science Press Printing Company, Lime and Green Streets, Lancaster, Pennsylvania.

Correspondence regarding business policies of the Journal should be addressed to the Editor. The use of material published in the Journal is encouraged and a liberal policy will be followed concerning reproduction of articles with proper notation as to source.

Your advertisement is being read in every State and in 25 Foreign Countries

THE AMERICAN JOURNAL OF PUBLIC HEALTH

Official Publication of the

AMERICAN PUBLIC HEALTH ASSOCIATION

The Journal publishes many important contributions to dairy science

A file of Journals for a year and the Association's Year Book, which is included in the subscription price of $5.00, constitutes a complete annual record of significant developments in public health as they relate to dairy science.

Send $5.00 to

The American Public Health Association

450 Seventh Avenue **New York, N. Y.**

MARSCHALL'S

for dependable help in the cheese vat

RENNET EXTRACT
RENNET POWDER
CHEESE COLOR
D-S-D Disinfectant

Samples and detailed information gladly furnished

MARSCHALL RENNET AND COLOR — AMERICA'S FAVORITE BRAND

Marschall Dairy Laboratory

Madison, Wisconsin
U. S. A.

THE SCIENCE PRESS PRINTING COMPANY

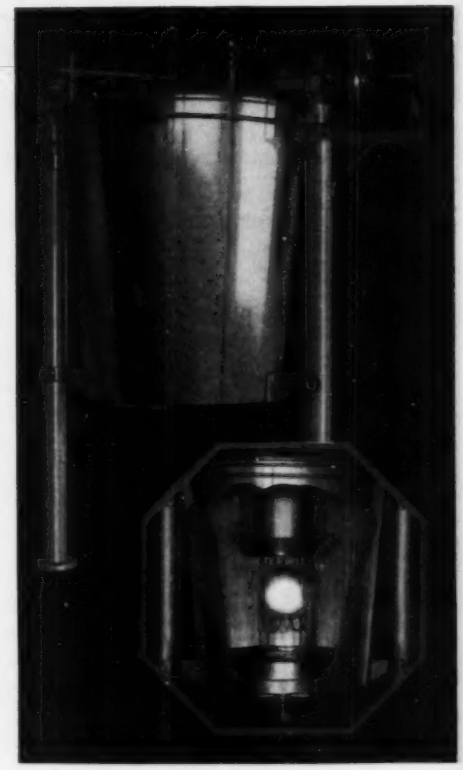
Printers of
Scientific and Educational
Journals, Monographs and
Books

Information furnished and detailed estimates submitted

Lime and Green Streets
Lancaster, Pennsylvania

Your advertisement is being read in every State and in 25 Foreign Countries

4 Things you should know about IRRADIATED VITAMIN "D" MILK



1. Vitamin D can now be imparted to milk in any volume, at a small fraction of a cent per quart, *right in your plant*, by irradiation or exposure of the milk to ultra-violet light in the milk plant. Your present operating arrangement is not disturbed. No special labor problem is involved. *No foreign substance is added.*

2. The vitamin thus developed is in remarkably effective form, as potent, "unit" for "unit" as Vitamin D in any other form, according to clinical test results which are beyond dispute.

3. The CP Milk Irradiator is 67% more efficient in light exposure and therefore in power costs than any other equipment now available for irradiating. It is the only commercial unit on the market designed specifically to perform this function.

4. You can assure your patrons that Irradiated Milk has a new protective value in the human diet. Irradiated Milk definitely prevents rickets. It has a place in the dental picture. It protects mothers during pregnancy. It corrects a diet deficiency which is well-nigh universal among people of all ages.

Those are the facts. Here is our suggestion:

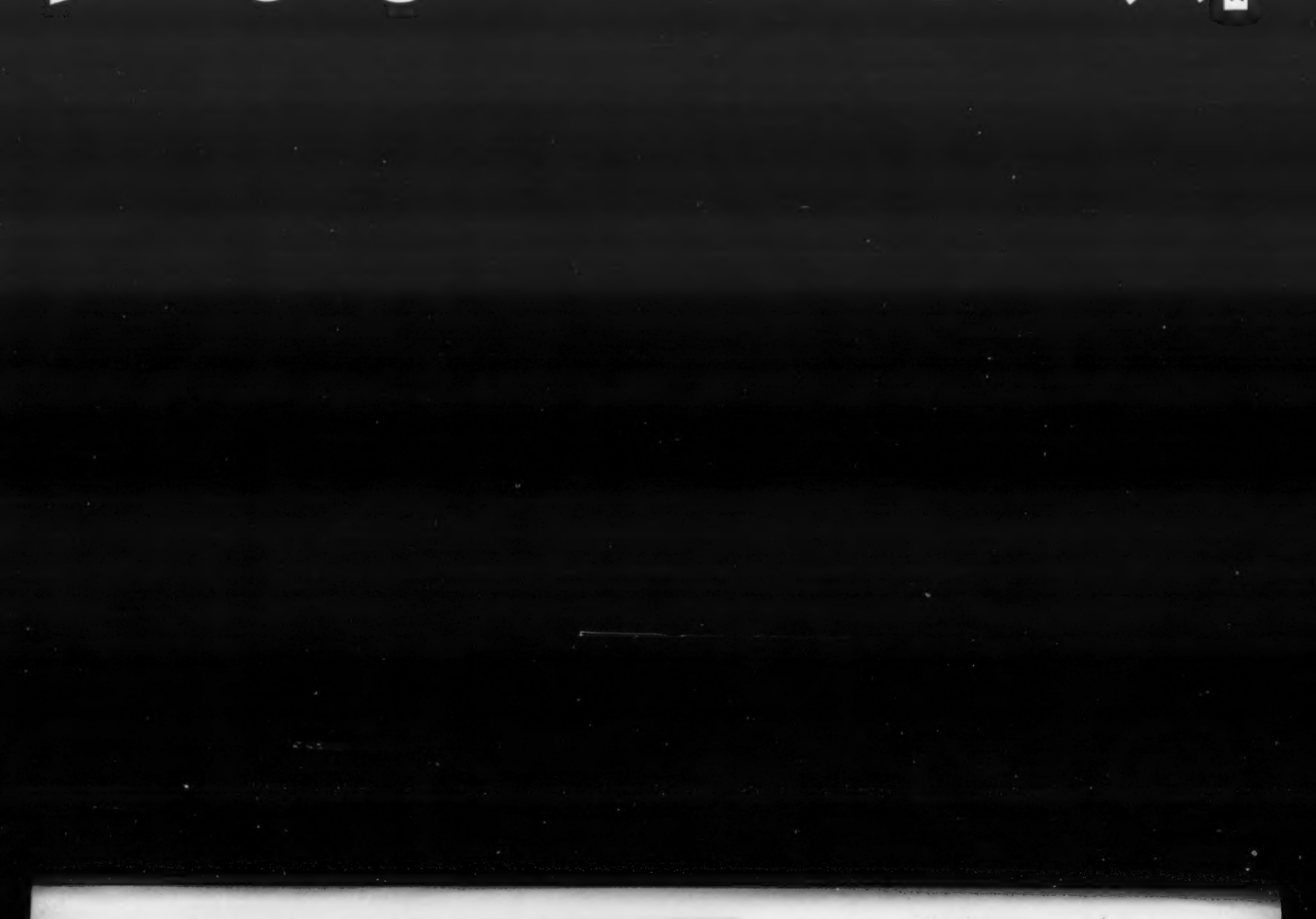
The dramatic story of Irradiation when properly announced and explained in advertising will help you increase your sales volume and your profits to a new level, largely by increasing per-capita consumption. Why shouldn't your firm be among the first to tell this story?

NRA MEMBER U.S. WE DO OUR PART

Whether your personal interest is scientific or commercial, we have further facts for you.

THE CREAMERY PACKAGE MFG. COMPANY, 1243 W. Washington Blvd., Chicago, Ill. Branches: Atlanta, Boston, Brooklyn, Buffalo, Chicago, Denver, Kansas City, Los Angeles, Minneapolis, Omaha, Philadelphia, Portland, Ore., San Francisco, Seattle, Toledo, Waterloo, Ia.

Your advertisement is being read in every State and in 25 Foreign Countries



Correct Cleaning

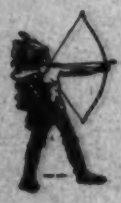
Pays Profits

DAIRY cleaning operations are too frequently considered merely as a necessary part of dairy overhead expense. Correct cleaning, however, will pay you a profit.

Correct cleaning means securing truly sanitary conditions, removing fat and casein accumulations where bacteria and molds breed. It means lessened time and effort. It means the protection instead of deterioration of equipment.

Correct cleaning, to thousands of the finest dairy plants, means cleaning with Wyandotte Dairyman's Cleaner and Cleanser. They have found, and you too will find, that it pays to clean with Wyandotte.

Order from your Supply Man or write for detailed information.



Wyandotte Dairyman's Cleaner and Cleanser

THE J. B. FORD COMPANY **Wyandotte, Michigan**

DIFCO

Bacto-Nutrient Agar

for the Standard Plate Count of Milk

Bacto-Nutrient Agar, when made up for use in the laboratory, meets every requirement of the standard medium for bacterial plate counts of milk as recommended in "Standard Methods of Milk Examination" of the American Public Health Association.

All lots of medium prepared from the dehydrated product are uniform. Neither filtration of the medium nor adjustment of its reaction is necessary. The reaction is standardized to fall within the permissible limits of variation.

Comparable bacterial counts are invariably secured over extended periods of time or in widely separated laboratories.

Specify "Difco"

THE TRADE NAME OF THE PIONEERS
IN THE RESEARCH AND DEVELOPMENT OF BACTO-PEPTONE AND
DEHYDRATED CULTURE MEDIA

DIFCO LABORATORIES

DETROIT, MICHIGAN, U. S. A.
Bacteriological Division of Digestive Ferments Co.

JOURNAL OF DAIRY SCIENCE

Official Organ of
American Dairy Science Association

Agents in Foreign Countries

For Argentina and Uruguay: Bautelspacher y Cia, Sarmiento 815, Buenos Aires.

For Australia: Angus & Robertson, Limited, 89–95 Castlereagh Street, Sydney; Stirling & Co., 317 Collins Street, Melbourne.

For Belgium: Henri Lamertin, 58 Rue Condenberg, Bruxelles.

For the British Empire, except Australia and Canada: Baillière, Tindall & Cox, 8 Henrietta St., Covent Garden, W. C. 2, London.

For Canada: Wm. Dawson & Son, Ltd., 87 Queen Street East, Toronto.

For China: Commercial Press Ltd., Paoshan Road, Shanghai, China.

For Denmark: H. Hagerup's Boghandel, Gothersgade 30, Kjöbenhavn.

For France: Emile Bougault, 48 Rue des Ecoles, Paris.

For Germany: B. Westermann Co., Inc., Krausenstrasse 38, Berlin NW 19, Germany.

For Holland: Scheltema & Holkema, Rokin 74–76, Amsterdam.

For Japan and Korea: Maruzen Company, Ltd. (Maruzen-Kabushiki-Kaisha), 11 to 16 Nihonbashi Tori-Sanchome, Tokyo; Fukuoka, Osaka, Kyoto, and Sendai, Japan.

For Spain: Ruiz Hermanos, Plaza de Santa Ana, 13, Madrid.

Subscription price is $5.50 per volume, postpaid, except in Canada and countries within the Postal Union where the price is $5.00.

The Science Press Printing Company,
Lancaster, Pa., U. S. A.